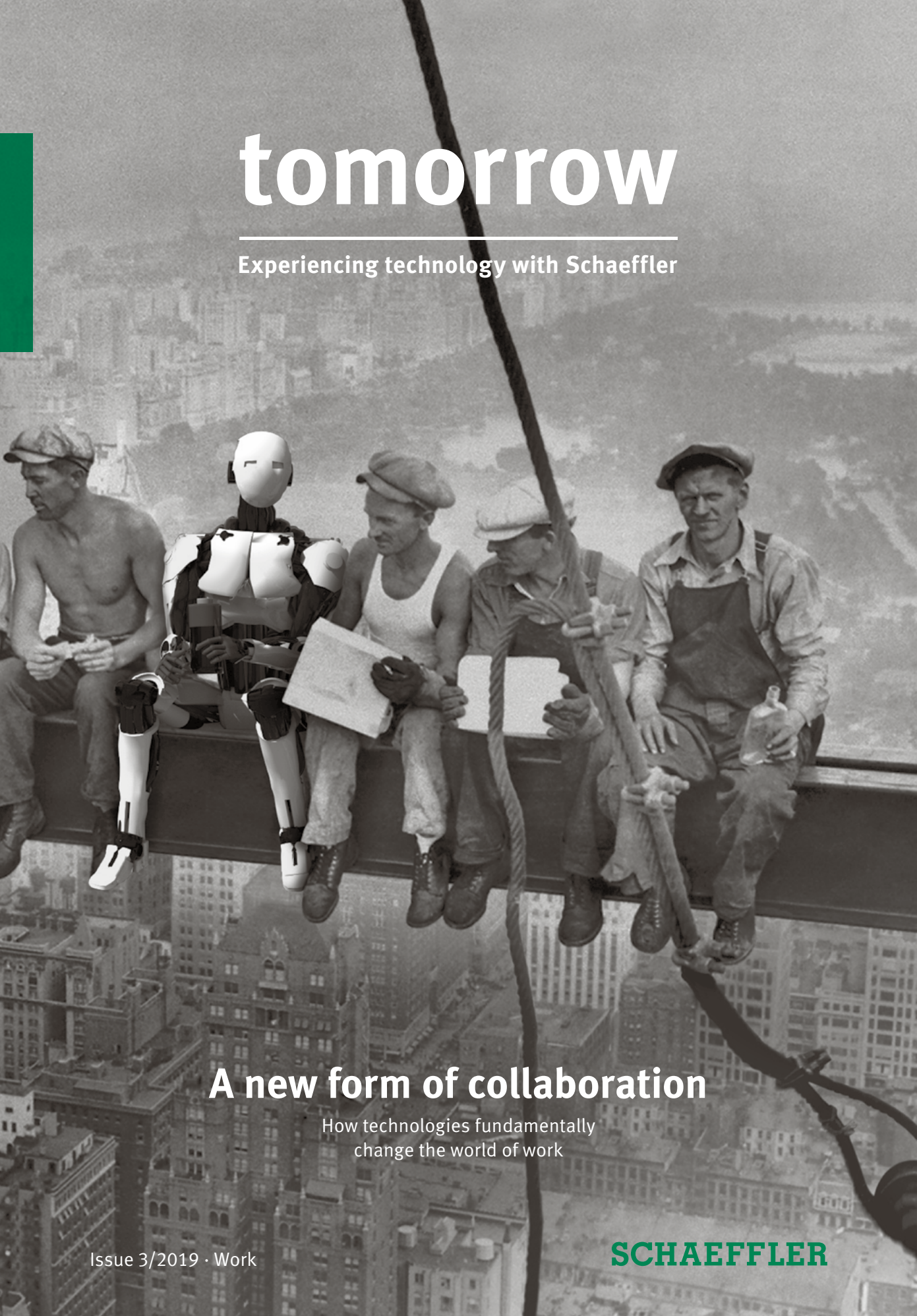
tomorrow

Experiencing technology with Schaeffler



A new form of collaboration

How technologies fundamentally change the world of work

Issue 3/2019 · Work

SCHAEFFLER

Work; - [wɜ:k]

Work is a word generally embodying concepts associated with the labor, force, energy, and/or effort required to produce a specific result. It may refer to:

1 **Human labour**
House work, management of a home
Manual work, physical work done by people
Schoolwork, work assigned by a teacher, school, or other educational institution
Wage labour, relationship in which a worker sells labour and an employer buys it
Work (project management), the effort applied to produce a deliverable or accomplish a task
Work ethic, the principle that hard work is intrinsically virtuous or worthy of reward

2 **Science**
Work (electrical), the energy transferred by a force from an electric field acting on a charge through a distance
Work (physics), the energy transferred by a force acting through a distance
Work (thermodynamics), the energy transferred from one system to another by macroscopic forces measurable in the surroundings

Source: Wikipedia, Retrieved on November 26, 2019 from https://en.wikipedia.org/wiki/Work

Dear Reader,

Some people say that half of our lifetime is spent working. What does your personal account look like? I'd say that work accounts for more than half of our life. Work goes far beyond the things we do in our jobs. After hours, household chores or perhaps gardening or yard work may be waiting for us. At the gym, we work on our fitness and at night school, on learning a foreign language. Plus, I'm sure all parents will agree with me that the job of parenting is one of the most challenging types of work. Just these few examples show that a separation between working and living – whether in 50/50, 60/40 or 40/60 ratios – is difficult, if not impossible. Life is work and vice versa. Or as Pablo Picasso once put it: "For me, working means breathing. If I cannot work, I cannot breathe." With these reflections about life and labor, I'd like to welcome you to the current issue of our technology magazine "tomorrow," in which 100 pages are fully focused on the topic of "work."

With the skills of his body and the creativity of his mind, Picasso created masterpieces – and drew the energy for his existence from them. Naturally, the creation of world-famous masterpieces is a privilege not many people enjoy, yet all of us know the sense of satisfaction when we can say "It's a wrap!" at the end of a project. However, work is not just the fuel for our self-esteem. Work provides our lives with structure. On good and bad days, or to quote the Enlightenment philosopher Voltaire: "Work saves us from three great evils: boredom, vice and need."

Clearly, work not only but also serves to earn a living, which takes us to the professional world. And this world is currently in a process of transformation that's equally fundamental and fast. Technological progress is working at full steam in this respect, too. Computers, robots and machines will be handling more and more of our routine jobs, while other jobs will simply no longer be needed due to changing markets. On the other hand, numerous new jobs will emerge, many of which will have titles and job descriptions we don't even know yet today. This is another topic covered by the current issue of "tomorrow." Looking back on past centuries provides peace of mind: progress has continuously changed the labor market – and always caused it to grow. The following figures also encourage us to interpret the current changes primarily as opportunities: in the first decade of our millennium, the digital transformation has led to the Europe-wide loss of 9.6 million jobs – and the creation of 21 million new ones, according to ZEW – Leibnitz Centre for European Economic Research.

These statistics show that it pays to join the journey of change. At Schaeffler, we're firmly convinced of this. We hope you will share our fascination with the transformation of "work" – on the following pages. Enjoy the read.

Klaus Rosenfeld
Chief Executive Officer

Global

A glimpse of the world

In motion

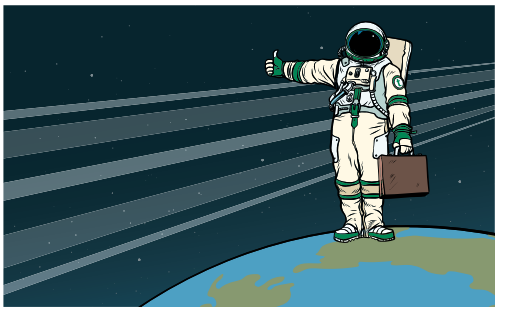
Innovations in the course of time

Here and now

Living with progress

Outlook

Technology for tomorrow



Global

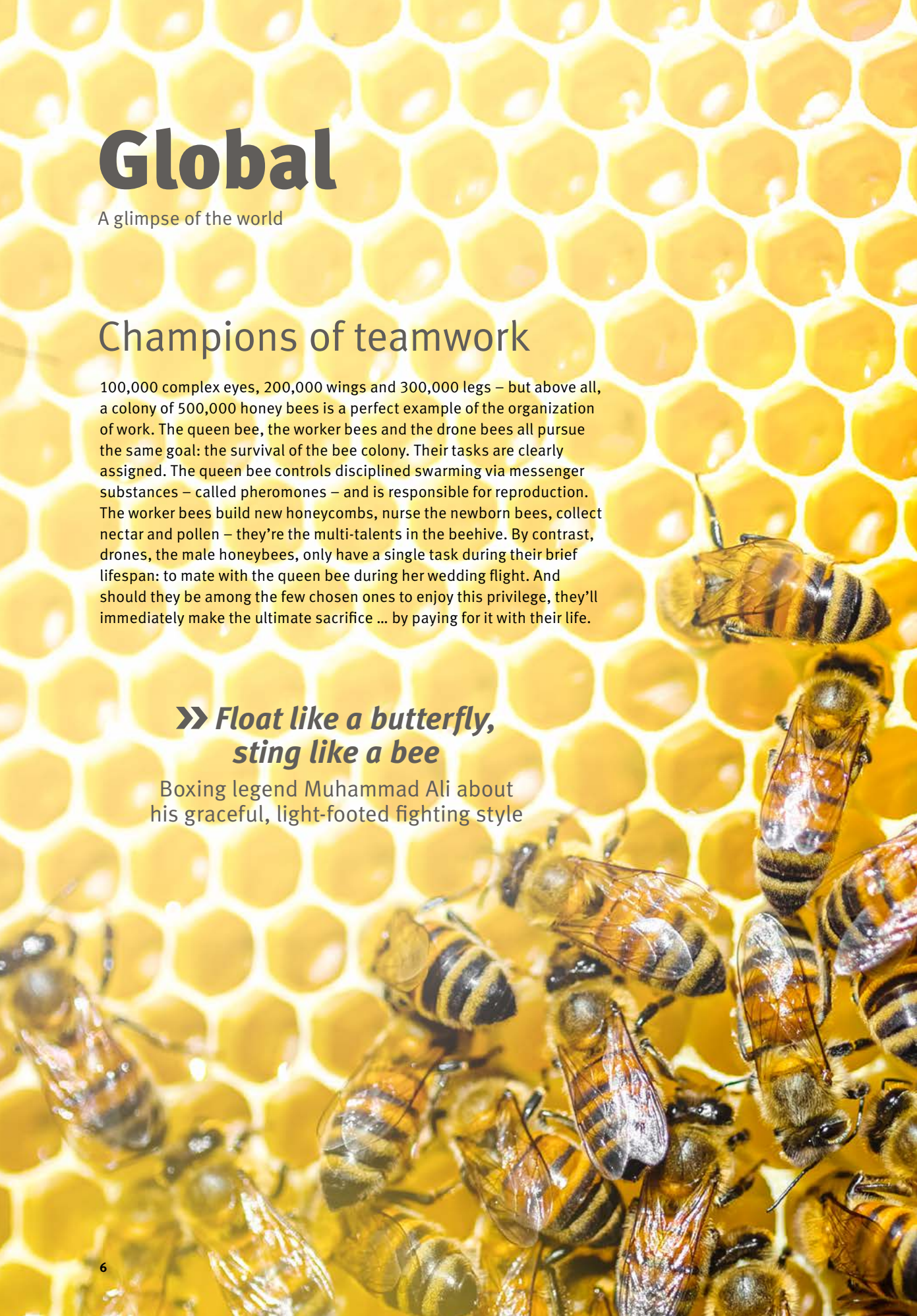
A glimpse of the world

Champions of teamwork

100,000 complex eyes, 200,000 wings and 300,000 legs – but above all, a colony of 500,000 honey bees is a perfect example of the organization of work. The queen bee, the worker bees and the drone bees all pursue the same goal: the survival of the bee colony. Their tasks are clearly assigned. The queen bee controls disciplined swarming via messenger substances – called pheromones – and is responsible for reproduction. The worker bees build new honeycombs, nurse the newborn bees, collect nectar and pollen – they're the multi-talents in the beehive. By contrast, drones, the male honeybees, only have a single task during their brief lifespan: to mate with the queen bee during her wedding flight. And should they be among the few chosen ones to enjoy this privilege, they'll immediately make the ultimate sacrifice … by paying for it with their life.

» *Float like a butterfly, sting like a bee*

Boxing legend Muhammad Ali about his graceful, light-footed fighting style



For 1 kg

of honey in a jar, bees have to fly some **150,000 km (93,000 mi).**

Source: propolis-honig.de

€265 bn

This is the worldwide **economic value** of bees per year.

Source: 3sat.de

0.1 g

This is the average weight of **worker bees;** queens and drones weigh twice as much.

Source: "Bienenblues", Jasmin Köchl

In 1984

bees traveled through **space** on the Challenger shuttle and built a nest – in spite of zero gravity.

Source: sueddeutsche.de

85 %

of the **vegetable and fruit growing** yield in Germany depends on honeybee pollination.

Source: deutscherimkerbund.de

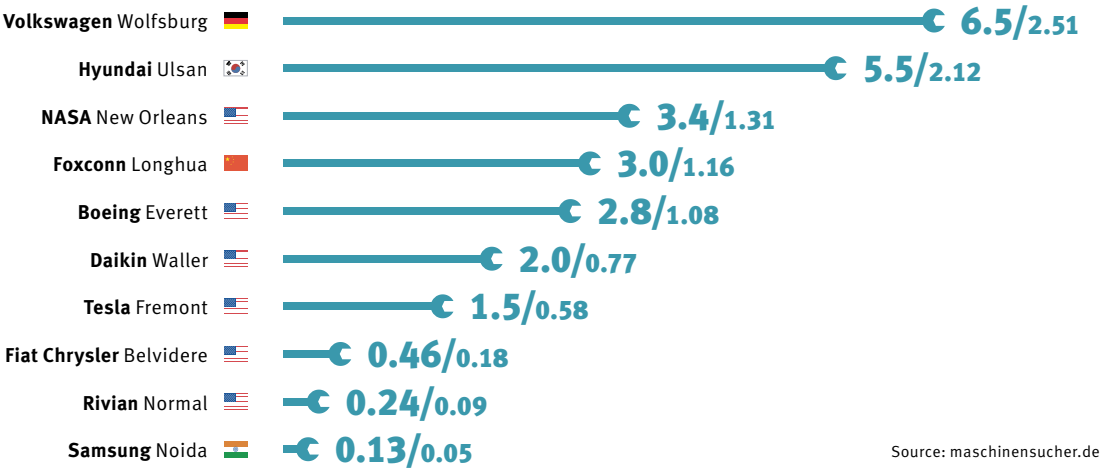
360° Work

Facts, figures, oddities – a 360-degree view of the focus topic of this issue of “tomorrow.”

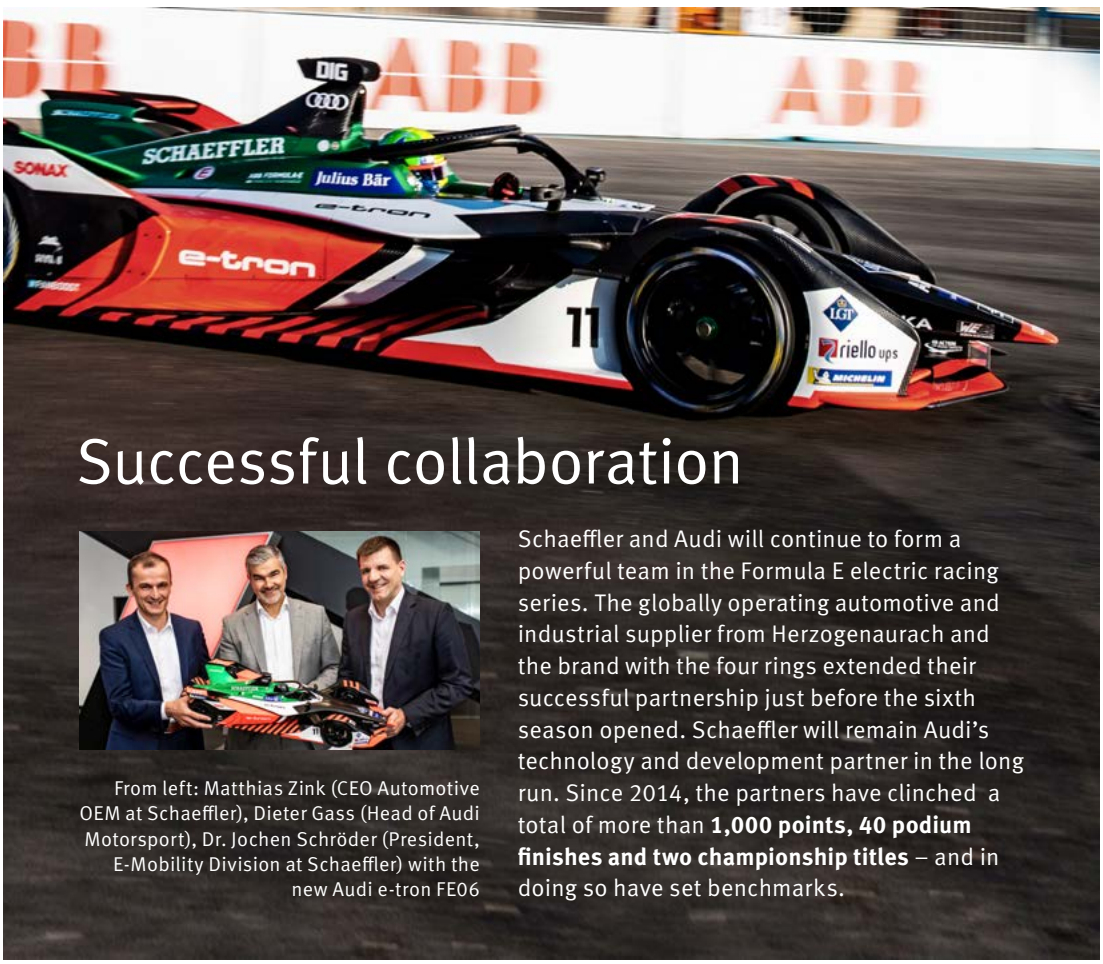
Heavyweight

The job of deep sea divers is heavy duty – literally speaking. Wearing an Exosuit, a special atmospheric diving suit, they can dive down to depths of some 300 meters (1,000 feet). This aluminum behemoth that cannot stand on land on its own weighs up to 250 kilograms (550 pounds), which makes it **the world’s heaviest type of work clothing.** With a price tag of 1.4 million dollars, it’s also one of the most expensive.

The 10 largest factories in square km/square mi



Source: maschinensucher.de



Successful collaboration

From left: Matthias Zink (CEO Automotive OEM at Schaeffler), Dieter Gass (Head of Audi Motorsport), Dr. Jochen Schröder (President, E-Mobility Division at Schaeffler) with the new Audi e-tron FE06

Schaeffler and Audi will continue to form a powerful team in the Formula E electric racing series. The globally operating automotive and industrial supplier from Herzogenaurach and the brand with the four rings extended their successful partnership just before the sixth season opened. Schaeffler will remain Audi's technology and development partner in the long run. Since 2014, the partners have clinched a total of more than **1,000 points, 40 podium finishes and two championship titles** – and in doing so have set benchmarks.

Children's dreams

Favorite professions of children

What do children want to be when they grow up? Police officers and teachers. In five countries on five continents, these two professions are always in the top three named.

	Boys			Girls		
Germany	19 % Police officer	10 % Pilot	6 % Fire fighter	22 % Veterinarian	9 % Teacher	8 % Physician
Australia	37 % Athlete	15 % Police officer	7 % Engineer	26 % Teacher	13 % Athlete	9 % Veterinarian
China	20 % Scientist	17 % Police officer	14 % Firefighter/ Soldier	29 % Teacher	16 % Dancer	14 % Artist
Uganda	28 % Driver	20 % Police officer	20 % Pilot	58 % Teacher	21 % Nurse	8 % Physician
Mexico	18 % Physician	16 % Police officer	13 % Athlete	23 % Veterinarian	18 % Teacher	16 % Fashion designer

Source: Education and Employers, forschung-und-wissen.de

Collaborative effort

All for one, one for all: Wikipedia is arguably the world's only project everyone can participate in. By now the online encyclopedia that has been accessible on the worldwide web since January 15, 2001 encompasses **more than 51.5 million articles in 297 languages.**

Words to remember

» Work is life, you know, and without it, there's nothing but fear and insecurity

John Lennon (1940–1980),
music legend

» Pleasure in the job puts perfection in the work

Aristotle (384–322 BC),
Greek philosopher

» Personalities are not formed by rhetoric but by work and personal achievement

Albert Einstein (1879–1955),
Physicist

» Work smart, not hard

Dr. Gregory House,
TV doctor

» I never dreamed about success, I worked for it

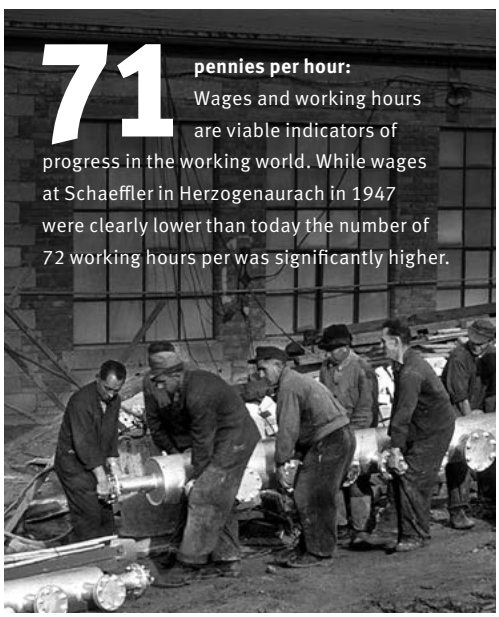
Estée Lauder (1906–2004),
American cosmetics entrepreneur

» Work! Nothing but work! Disgusting!

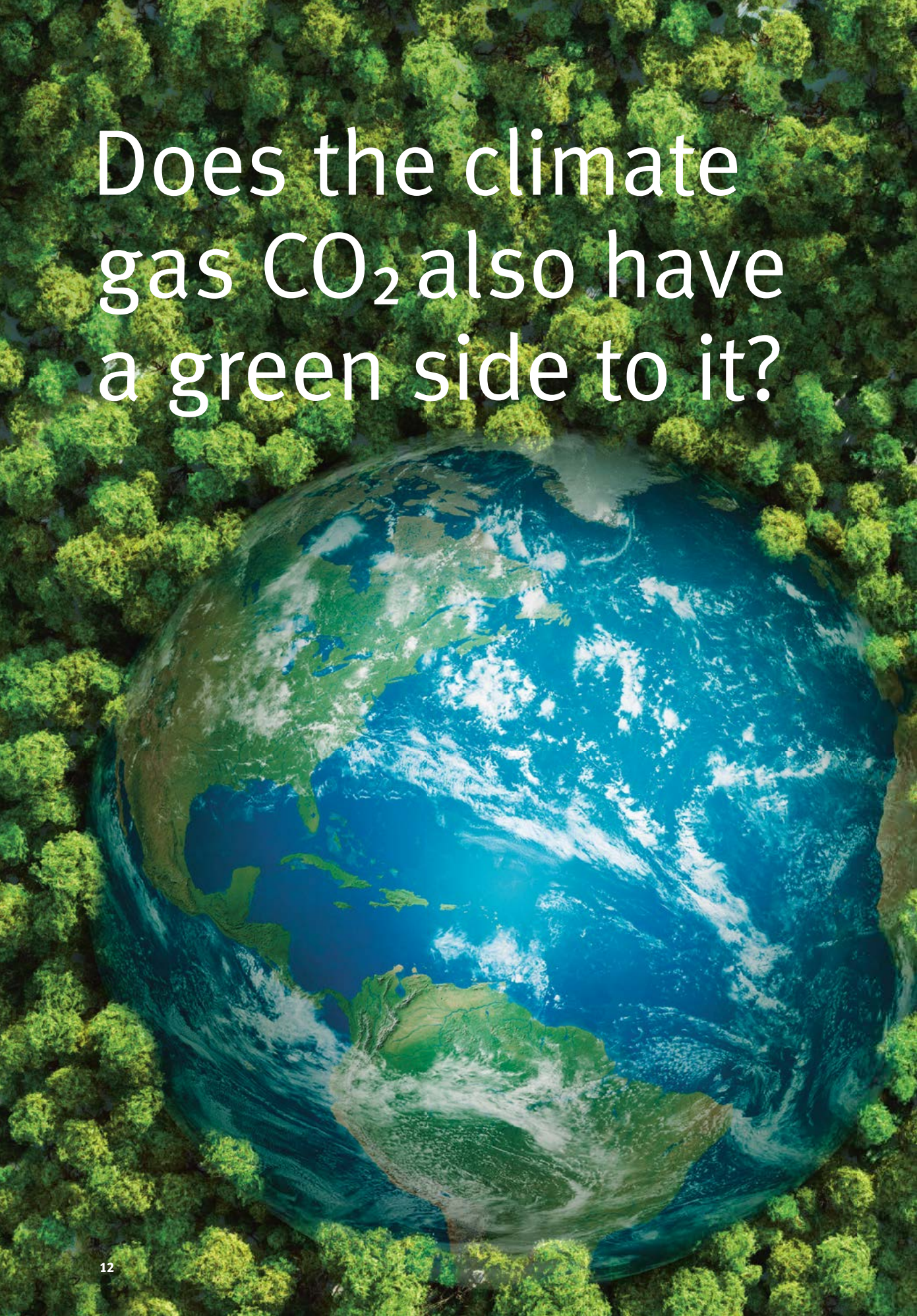
Donald Duck,
cartoon character

Time killer email

Efficiency is an important factor in modern day-to-day work. Even so, there are numerous time killers that regularly consume resources. Emails are still one of the biggest ones. Employees spend **more than three hours a day** checking business emails, according to a recent Adobe survey. Consequently, some companies are now pursuing a zero email strategy.



Does the climate gas CO_2 also have a green side to it?



Whereas all previous plans revolved around storing the climate gas CO_2 in underground layers of rock or just getting rid of it, it's now supposed to be converted into a valuable raw material. Mattresses, carbon fibers and fuel: experts are working on the sensible utilization of CO_2 to manufacture these and other products.

By Denis Dilba

If Dr. Markus Steilemann has his way more and more people will soon be able to snooze on the climate killer CO_2. The CEO of polymers supplier Covestro in Leverkusen is referring to the first products of the company's "Dream Production" facility in Dormagen that was launched about three years ago. This is where Covestro – with the help of the notorious carbon dioxide – produces some 5,000 metric tons (5,500 short tons) of polyol per year – a substance that's required for polyurethane foam in upholstered furniture and mattresses, etc. In a second stage, this chemical, which is normally produced completely from the carbon in petroleum, is planned to be used for the production of insulating materials for buildings or refrigerators and air conditioning systems.

CO_2 to replace petroleum as a raw material

The subsidiary of chemical giant Bayer is one of the first companies in Germany to use carbon dioxide as a raw material for polymer production on an industrial scale – instead of dismissing it as undesirable waste. "With CO_2 as a carbon supplier, we're increasingly able to dispense with traditional fossil sources like petroleum," says Covestro's chemist Dr. Christoph Gürtler, who developed the facility's processes in collaboration with the Catalytic Center of RWTH Aachen. Experts generally refer to this process as "carbon capture and utilization" (CCU). Thus, the climate gas is beginning to see a change in image: Previously, the main idea had been to pump the fraction of CO_2 that cannot be avoided by switching to alternative propulsion or production technologies into underground storage areas. There, preferably captured forever in layers of rock, carbon dioxide was supposed to do no more harm.

CO_2 recycling is still in its infancy

Now the idea is to recycle the climate gas. This concept has begun to inspire widespread enthusiasm among the international scientific

research community: All over the world, work on new efficient methods is in full swing. Not a month goes by without an announcement of new successes and products. U.S. scientists, for instance, produced carbon fibers from CO_2 by means of electrolysis. In this way, it may even be possible in the future to produce this lightweight material at lower costs than by using conventional methods. Carbon Clean Solutions in the UK has presented a process that produces sodium carbonate, a pre-product of baking soda, using the carbon dioxide captured from the emissions of a coal-fired power-plant in a very economical way. The versatile sodium carbonate, colloquially known as soda, is also used in the production of paper, glass, adhesives, detergents and soap.

Success without subsidies

While the London-based company is not the first to produce soda from CO_2 it's the first one to have launched such a technology without government funding assistance. The company says that its product can be produced at costs which are two to three times lower than those of conventionally produced soda. A new chemical for filtering CO_2 developed by Carbon Clean Solutions makes this competitive pricing possible. Compared with the currently used substance family of amines, it's said to be more efficient, lower-cost and less corrosive, as well as requiring less energy to separate the captured carbon dioxide and being suitable for use even in smaller apparatus. A remarkable achievement considering that most CCU technologies are still thwarted by lack of economic feasibility.

Only minimal climate protection?

To marry the chemically inert CO_2 with other chemicals it needs a boost, which typically requires a substance facilitating the desired reaction – a so-called catalyst – plus plenty of energy that has to be supplied from an external source. Both combined cost time, lots of money and, in turn, frequently release carbon dioxide. Therefore, environmental organizations such as the WWF and Greenpeace criticize the development of CO_2 recycling technologies as green-washing by the corporate world. However, industry is well aware of the fact that CCU will not save the planet overnight: "Of course the amounts of CO_2 that can be used for the synthesis of such chemicals are very small compared to the annual CO_2 emissions so that the effects on the climate will initially be small," says Thomas Schaub, who is working on the production of the chemical formaldehyde from CO_2 at BASF.

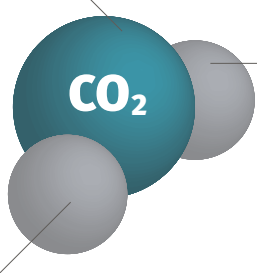
Climate-neutral with renewable energy

Only if the energy for CCU processes were CO_2-free as well, for instance by using wind power or photovoltaics, CCU would actually consume CO_2. "But you've got to start somewhere," says Schaub. The advantage of carbon dioxide, the scientist adds,

37,100

metric megatons (41,000 short megatons) of CO_2 from fossil fuels were emitted by humans **worldwide** in 2017 – more than ever before.

Source: The Global Carbon Project



580,000

metric megatons (640,000 short megatons) of CO_2 can still be emitted by us, after that the **1.5-degree global warming goal can no longer be met.** Based on current emissions, this will cover a period of about 14 years (as of the beginning of 2018).

Source: IPCC of the United Nations

1,900

metric megatons (2,100 short megatons) of CO_2 could be **sensibly converted Europe-wide.** This accounts for about 54 percent of Europe-wide CO_2 emissions (as of 2017).

Source: Institute for Advanced Sustainability Studies (IASS), Potsdam

Above: By means of CO_2 Covestro produces the polymer polyol in this complex production facility

Below, left: The specialists also use CO_2 to produce binding agents for elastic floors in sports facilities

Below, right: A team headed by research scientist Dr. Christoph Gürtler has discovered the right catalyst for using CO_2 in the production of polyol. Soft foam for mattresses is an initial application

is that's available in very large amounts and at very low cost. However, it's not clear yet whether Schaub will actually be able to produce formaldehyde, an important raw material for various plastics, from CO_2 in the future. He and his team are currently looking for a catalyst that will make the reaction economically feasible. At least the results they've obtained so far look promising. In any event, such projects are important in paving the way for using CO_2 as a raw material, says the chemist Schaub. "The technologies developed in the process can later be fed into significantly larger applications such as the production of liquid fuels."

Component for climate protection

A number of other companies are planning or operating similar plants for fuels or fuel additives: RWE, Audi, LanzaTech, Carbon Engineering, Global Thermostat, Nordic Blue Crude and Ineratec, to name just a few. "However, there's no technology that has come out on

CO_2 statistics

Worldwide carbon dioxide emissions from fossil fuels in 2017

Sources: International Energy Agency, European Environment Agency, CO_2 Report by the Joint Research Center (JRC)

37,100
metric megatons of CO_2
(41,000 short megatons)

Half of which is attributed to the **three major emitters**

10,900 (12,000) China
5,100 (5,600) USA
2,500 (2,750) India

EU share of worldwide CO_2 emissions in percent

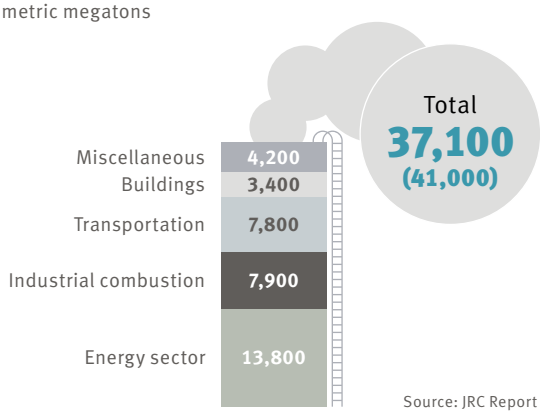
19.9
1990

9.4
2017

0.95
metric megatons (1.05 short megatons) of CO_2 in a total of 3,500 metric megatons (3,850 short megatons) in the EU in 2017 were caused by transportation

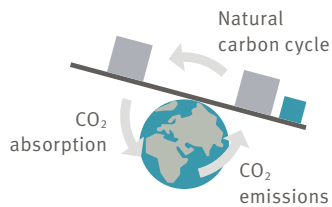
Worldwide CO_2 emissions in 2017 by sectors

in metric megatons



Source: JRC Report

Humans upset the CO_2 equilibrium



280 ppm* CO_2
104 ppm CO_2
Additional human input since 1750

*ppm = parts per million
(Parts per 1 million air molecules)
Source: World Climate Council

CO_2 as a valuable raw material

CO_2

Petroleum

Up to
20 %
petroleum could be **replaced** by CO_2

Sleeping on CO_2
Soft foam for mattresses

Fit with CO_2
Binding agent for sports facility floors

CO_2 for wearables
Elastic fibers for the textile industry

Projects in the pipeline
Building, driving, cooling, washing with CO_2

Source: Covestro

Advantages of Iceland

The Icelandic company Carbon Recycling International (CRI) has been using the advantages of the island in the North Atlantic for more than seven years: A geothermal power station delivers free waste heat and low-cost electricity as well as the climate gas in suitable concentrations. It rises there from the Earth's crust. CRI produces 4,000 metric tons (4,400 short tons) of methanol per year in this way. The Icelandic company has now developed the process to a level at which it also runs with CO_2 captured from the waste gases of chemical, steel and cement plants. Their next plant will be at least ten to twenty times larger and produce up to one hundred thousand metric tons (110,000 short tons) of methanol per year, according to Benedikt Stefánsson, Head of Business Development at CRI. In two years, the first large-scale production facility of this kind is planned to be launched in China.

top yet in the production of such synthetic fuels," says Georg Kobiela from the Wuppertal Institute for Climate, Environment and Energy. However, the expert in future energy and industrial systems cautions that, without additional supporting actions, relevant production quantities will not be achieved for a long time whether in the area of fuel production from CO_2 or with most other CCU technologies in the chemical industry. "At this juncture, we're talking about a decade and longer," the scientist admits and therefore proposes instruments such as funding support, purchasing guarantees for the products, and opportunities for faster tax depreciation of the requisite equipment in order to accelerate the development of CCU technologies. "Because, clearly, we need it – as one component among many other actions that are required for climate protection."

Perpetual motion through genetic engineering?

Meanwhile scientists like Daniel Nocera from Harvard University in the United States are working on the really big solution: artificial photosynthesis. His bionic leaf initially converts sunlight, carbon dioxide and water into hydrogen and oxygen. Genetically engineered bacteria subsequently absorb the hydrogen and together with carbon dioxide process it into biomass or other CO_2-based base chemicals. In this way, an artificial carbon cycle might actually become a reality. If and when it does, the carbon dioxide emitted by automobiles, aircraft, ships and factories could just be captured by artificial leaves and transformed into fuel. However, we should not (yet) depend on this to happen.

The author

Following his research for this article, technology journalist and engineer **Denis Dilba,** may opt for a CO_2 model when purchasing his next mattress. He would also have a use for CO_2-based synthetic diesel. The only question is whether his old VW van will hold up until the green fuel hits the filling stations.

Out of office

It doesn't always have to be a desk. These ten people have a slightly different workplace.

By Wiebke Brauer

Christina Koch (above and selfie at left) has four spacewalks under her belt. Together with her colleague Jessica Meir on the fourth one, she made space exploration history

The astronaut

Working in weightlessness

This woman is really out of this world. Since March 19, 2019, U.S. astronaut **Christina Koch** has been working in and on the ISS space station. In October, the electrical engineer made space exploration history. Once again, one might add, because the 40-year-old holds the record of a woman's longest stay in space to date. Now Koch is even part of the first all-female spacewalk crew. Following three previous extra-vehicular activity (EVA) missions accompanied by a male astronaut, Koch on her fourth one left the ISS together with her colleague Jessica Meir. The two astronauts replaced a charge/discharge unit for lithium-ion batteries supplying the solar array with electric power. In an interview before the all-female mission that made worldwide headlines, Meir had commented, "The nice thing for us is we don't even think about it on a daily basis. It's just normal, we're just part of the team …"

7:17 hours

This is how long **the first all-female EVA mission** lasted. During this period of time, the ISS orbits the Earth nearly five times. Koch's earlier spacewalks were similarly long.

38 °C (100 °F)

This is the **body temperature in space,** one degree (1.5 °F) more than on the Earth. Under physical strain, it may rise to 40 °C (104 °F) because perspiration that cools the body is inhibited in a weightless environment.

The marine biologist

H_2O in her genes

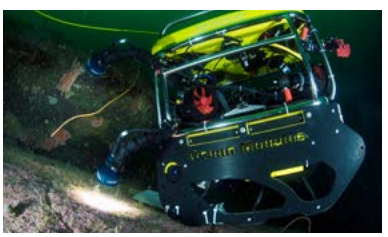
Her grandfather was a captain and whale catcher and as a child she was fascinated by the films of Jacques-Yves Cousteau or Lotte and Hans Hass – with a personal history like that, maybe you've got no choice but to pursue a marine career. **Antje Boetius** is a deep sea explorer, although that description falls a little short of her professional scope: Since November 2017, the 52-year-old has been at the helm of the Alfred Wegener Institute for Polar and Marine Research in Bremerhaven with branch offices in Potsdam and on the islands of Helgoland and Sylt – with a total of 1,250 employees, In addition, Boetius is a professor of geo microbiology at University of Bremen and leads a research team for deep sea ecology and technology at the Max Planck Institute for Marine Microbiology. During her professional career, she has led nearly 50 expeditions, spent several years at sea in total and performed several deep sea dives. Just 150 years ago, it was assumed that it was impossible for any life to exist between four to eleven thousand meters (14,000 to 36,000 feet) below sea level. Far from it, as the deep sea is home to millions of species. Nobody can exactly tell how many. "There have been fewer people in the deep sea than in outer space," says Boetius. She describes diving into this alien world like this: "At the top, sunlight shines through the ocean layers. That's when you can see all kinds of hues of blue. Once you've arrived at a depth of 400 meters (13,000 feet), you're floating in total darkness." When the onboard lamps are switched off you can see the glow of luminescent bacteria, fish and jellyfish. The researcher describes this spectacle as "fireworks in the dark."

in 2000

Boetius proved the **existence of methane-eating microorganisms** in the deep sea. The single-celled organisms prevent the fermentation gas, which is 22 times more harmful to the climate than CO_2, from reaching the atmosphere.

88 %

of the oceans or 62 % of the Earth's surface **are deep sea areas.** The deep sea begins at 200 meters (650 feet) below the water surface. The temperature range there is relatively stable between –1 and +4 °C (30 and 39 °F).



Be it on board of the German research vessel "Polarstern" or a submarine: deep sea researcher Boetius feels at home both under and above water. Her grandfather survived the sinking of three ships

The field service engineer

Tiny dust particles, huge bearings

Americans like to give nicknames to their states. Arizona's is the "The Copper State" – due to its ample copper deposits. **Michael Wernke** is one of the people who help mine the precious metal. About four times a year, the Schaeffler field service engineer roams the remote, Martian-like landscape of the region in order to provide crucial assistance to his customer Freeport-McMoRan in Morenci, Arizona's largest copper mine. Morenci is home to the world's biggest high-pressure grind roller for ore. To enhance the mine's productivity, Schaeffler developed the first sealed pendulum-type rolling bearing of this dimension – a solid unit with an outer diameter of nearly two meters (6.5 feet). This behemoth is part of Wernke's scope of responsibilities. The day in his "outdoor office" begins with a one-hour drive into the dusty mine region where a whole army of humongous machines is untiringly doing its work. The impressive grind roller with the no less impressive Schaeffler bearing is one of them. The huge component, which is sealed due to its extremely dusty work environment, initially posed an intriguing challenge to Wernke: how can you measure the clearance of a bearing whose rollers are the size of soccer balls and each of them weigh 50 kilos (110 lb)? "This component is a lot bigger than anything I've ever worked on before," says mechanical engineer Wernke almost with awe. His gift for technical things was obvious at an early age: just three years old, he dismantled the family's vacuum cleaner! Now the man who's 1.93 meters (6.3 ft) tall dismantles bearings that are as big as he is.

In spite of his height of 1.93 meters (6.3 ft), Schaeffler engineer Michael Wernke looks small next to the high-pressure grinding roller and inside the Schaeffler bearing, which is sealed due to the dusty work environment

115,000

metric tons (127,000 short tons) of copper ore per day are ground at the Morenci site.

126

heavy-duty dumpers, each with a load rating of 236 metric tons (260 short tons), supply the grinding mills with ore. The buckets of the laden excavators have a capacity of up to 57 m^3 (2,013 ft^3).

The stuntman

His motto: “Flat-out or not-at-all”

$300,000

This is how much the famous ice race in the 007 movie “On Her Majesty’s Secret Service” cost, which Glavitza choreographed – **5 % of the movie’s total costs.**

0

injuries. Glavitza was never hurt in any of his stunts or auto races. In motocross, he once cracked a cervical vertebra and in ice hockey was hit in the eye by a puck, which caused the retina to separate. Both injuries healed well.

For his movie, lead and producer Steve McQueen (pictured below, left) was looking for a stuntman who was good at crashing: Glavitza (pictured below, right, and above)

His work area often pushed the limits. “I’ve got no problem with rollovers.” Even so, **Erich Glavitza,** the man who said this, is now 77 years old. The Austrian’s work was often that of a daredevil but never suicidal. In his book “Vollgas oder nix: Meine wilden 60er mit Jochen Rindt, James Bond und Steve McQueen” (“Flat-out or not-at- all, my wild 60s with Jochen Rindt, James Bond and Steve McQueen”), all-rounder Glavitza describes his wildest rides and most unusual jobs. In the James Bond movie “On Her Majesty’s Secret Service,” he also did the stunts for Bond Girl Diana Rigg. No problem for him: “Actually, I only had to put on a fur hat.” Even though he worked with no holds barred in various movies, he doesn’t call himself a real stuntman. To be honest, he says, he only did on the set what he’d been doing all along: driving cars. The man who has a PhD in philosophy started racing cars in his youth and later motocross as well. Plus, he worked as a driving instructor. However, he also founded a company, Stunt Limited, together with a partner, Peter Huber, and worked on the set of “Le Mans,” the race driver movie which the lead, Steve McQueen, produced himself in 1970. “He was looking for someone who was able to crash realistically,” says Glavitza, who had this kind of skill. “You have to drive with precision down to an inch for this.” Discipline, he says, is essential to high-precision driving. Glavitza, who also did the stunts for McQueen’s opponent Siegfried Rauch, adds: “Of course that was dangerous. We went full speed. There was no such thing as slow turns and slow motion. Rolling over, crashing into walls – you do things like that when you’re young and dumb.”

€35 million

have been **invested in the construction of the facility** since 2000.

9

construction stages have been completed to date. A bridge to an adjacent building serves to develop new areas. The sections "Provence," South and Middle America" and "Asia" are planned to follow.

"Miniatur Wunderland" is one of the main attractions in the port city of Hamburg – and a highly fascinating workplace for Lars Rösenberg (below)

The train operator

Big picture of a small world

1,040 digitally controlled trains, 15,715 meters (51,560 feet) of track length, 3,454 switches, 1,380 signals, 9,250 cars, 52 aircraft: and all this on 1,499 square meters (16,135 square feet) at "Miniatur Wunderland" ("Miniature Wonderland") in Hamburg, the world's largest model railroad display. What seems like a playground to some is a normal place of work for **Lars Rösenberg.** He's a master industrial electrician and in charge of system control. The railroad operation, as Rösenberg calls it, encompasses everything from moving trains to cars to marine traffic. 45 people work on his team, albeit not all of them full-time. "We're responsible for ensuring that everything rotates and moves," says Rösenberg. The tourist attraction is open seven days a week. Every morning, the system has to be rebooted, which takes between 30 and 45 minutes – the most critical phase of the day. Rösenberg: "You have to watch how smoothly the system reboots, where faults appear or if a computer crashes." How he got this job? Very simple: Two weeks after completing his apprenticeship as an electrical technician, he privately visited "Miniatur Wunderland" – and decided to ask for a job. He was only 21 at the time. During the job interview, the electronics chief asked him if he had a model railroad at home. When he said that he didn't, he got the job. The reason is that a fascination with model railroads is one thing and a highly professional technology standard another. If you ask the 38-year-old today what the best thing is about his job, he pauses for a while and then shouts: "It's awesome! We keep such a mass of things in motion – and it's a miracle that it works."

4,000

people **live in Antarctica,** the fifth-largest continent, in the summer. In the cold and dark winter, only 1,000 do.

2

weeks of a specialized medical training have taught Amy Hobbs the requisite skills for assisting with surgical interventions.

Super climate at Casey Station: Amy Hobbs (left) and her team make sure of that by taking good care of the technology as a well-gelled crew

The polar scientist

For her, there's no such thing as "can't be done"

Sitting in Antarctica for months on end – that's something you have to enjoy. **Amy Hobbs** does. She's done two stints as the lead service engineer at Casey research station, an Australian research outpost on the Budd Coast in East Antarctica: one in summer (2017/2018) and one in the bitter-cold and dark polar winter (2019) when average temperatures on the coast are between minus 20 and minus 30 degrees centigrade (–4 and –22 °F). However, be it in summer or winter: survival in Antarctica is not possible without proper technical equipment. Keeping the technology in good repair is the job of Amy Hobbs and the team she leads. Hobbs is a woman for all seasons. "Working in an amazing environment with a great bunch of people, and having a laugh, even when the task at hand might not be the greatest. I help out the plumbers occasionally," says Hobbs, describing the work at Casey Station and what makes it special. And what does she do after hours? That's when the Australian enjoys the constantly changing light on the icebergs and on the sea at Newcomb Bay: "I don't think I'll ever have my fill of it," she says.

By 2021, India is expected to be the world's third-largest passenger car market. At the same time, vehicle technology is becoming increasingly complex, which makes it all the more important to train local mechanics

in 2018

Schaeffler Automotive Aftermarket established its **first Indian training center** in Mumbai.

70

Indian cities are on the itinerary of Schaeffler's REPXPERT **mobile training center.**

€1.859 billion

in **worldwide sales** were generated by Schaeffler's Automotive Aftermarket unit in 2018.

The parts explainer

Grassroots support

The places he works at are no clinically clean garages in glass palaces. **Himmat Singh's** grassroots explanatory work is performed in places that smell of oil and gasoline. For three years, he's been traveling across the Indian state of Rajasthan for Schaeffler's Automotive Aftermarket unit. His mission is to inform the garage pros who frequently work outdoors or in thin corrugated iron shacks of the advantages of clutch systems, transmission and suspension components made by the German supplier and to provide them with tips on how to install them. India is an emerging market. The automotive aftermarket there has grown by an annual 14 percent just in the past five years. "The interaction with the mechanics helps me gather feedback on our products. At the end of the day, it's all about customer satisfaction," says Singh.

The helicopter pilot

Precision in wood cutting

Wolfgang Jäger is not just flying around for fun. He trims trees and branches with his helicopter – whenever they protrude into train tracks, power lines or ski lifts. Jäger is just one of two pilots employed by the Austrian company Wucher Helicopter who are allowed to fly with a saw. Obviously, this is not a run-of-the-mill cutting device but a long system of linked aluminum tubes from which a 600-kilogram (1,320-lb) circular saw with up to ten rotating sawblades is suspended. The control cable from the saw is routed through the linkage to the cockpit from where the system is controlled. For emergencies, Jäger's control stick has a button with which the saw can be released, for instance when it hits an overhead power line. Extremely close teamwork is necessary to keep this from happening. The pilot is engaged in a constant exchange with a co-pilot and a control person on the ground. Jäger: "This is enormously important because on these missions, you have to fully focus on the saw. This involves a lot of high-precision work: it's not uncommon to cut something just at a 30-centimeter (1-foot) distance from a power line." If this weren't difficult enough, it's also possible for the saw to pick up too much momentum or be caught by a gust of wind. "We can fly up to a wind speed of about 45 km/h (28 mph). In stronger winds, it's too dangerous," says Jäger. However, he's never bungled a cutting job so far, he adds.

4,000 euros

This is the cost of **cutting trees with a helicopter** – per hour. In return, a distance of about 2 kilometers (1.2 miles) has been cleared.

6–8 years

That's how long a **helicopter cutting job** lasts. After that, nature has recaptured its terrain and it's time for the flying saw to do its job again.

45–60 hp

That's the output of the **flying saw's motors.** The fuel tank's capacity is enough for a 90-minute mission.

An infernal pendulum: anything that gets in the way of the flying saw with ten rotating blades is pulverized – so pilot Wolfgang Jäger has to fly with proper caution

›8,500

passenger cars, trucks, vans and other commercial vehicles have been equipped with Space Drive to date – plus an approved race car.

Position 4

was claimed by **ex-Formula One driver Markus Winkelhock** in the Space-Drive Audi from Schaeffler Paravan in the DMV GTC's final race

The vehicle converter

Personal meets professional passion

There's a reason for the broad smile on **Timo Haug's** face. His job has taken him to the place to which his private passion attracts him, too: the race track. Haug is an avid kart driver and motorsport fan. His job at Schaeffler Paravan has now resulted in a private and professional overlap. On the job, the 38-year-old equips vehicles for people with disabilities with Schaeffler Paravan's drive-by-wire technology Space Drive. In addition, Haug develops customized Space Drive solutions for prototypes – from microcars to trucks – for client projects. All in all, a highly varied field of work that in 2018 was extended by a very attractive facet: a race car with Space Drive. To demonstrate the capabilities of the technology on the one hand and to gain further development input from using the system at the limit on the other, Schaeffler-Paravan converted an Audi R8 LMS into a steer-by-wire race car. The steering column was removed and a force-feedback steering wheel operating with electrical impulses installed. Timo Haug was involved in the project from day one. The innovative race car was the first of its kind to be approved by the German Motorsport Association (DSMB) and competed in the DMV GTC series. For four races, Timo Haug switched from the production hall in the southern German town of Aichelau to the garages at race tracks like Nürburgring and Hockenheimring.
"It's exciting to keep developing this system under these extreme conditions," he says. "When the car raced past us at 250 km/h (155 mph) for the first time without a steering column, that was a real goose bump moment."

Whether on the grid or in the pit lane: Timo Haug is engaged in constant exchange with the race driver to obtain as much detailed feedback as possible. It's fed into the further development of Space Drive

The flow specialist

Ensuring that the mugs are filled

The Munich Oktoberfest is the world's biggest folk festival. 6.3 million people in partying mood flocked to the "Wiesn" in 2019. Most of them just came for one thing: drinking beer. A total of 7.3 million liters (1.93 million gallons) this year. **Uwe Daebel,** Head of Filling and Packaging Technology at the Paulaner Brewery, is the man who's instrumental in ensuring that the stream of beer never runs dry. His company is the supplier to 18 large and smaller beer tents at the Oktoberfest. It's a high-pressure job in more ways than one. Especially in the large tents, where up 9,300 people want to be served, the supply became increasingly difficult. Uwe Daebel rose to the challenge by coming up with the idea of using a ring line to supply each of the three largest tents with beer. Amazingly, "The system operates without mechanical pumps; only carbon dioxide acting as a pressurizer pumps the beer to the taps," Daebel explains. Sounds simple, but there's a lot control technology and software from Siemens working in the background. Via an internet connection, Daebel can read all the relevant data on his "Mug-o-Meter" from anywhere in the world: flow speed, consumption, pressures, temperatures, fill levels, and so on. First thing in the morning, Daebel looks at his "Mug-o-Meter" to check if the scheduled amount for the day was actually delivered overnight or, as Daemel puts it, if the tanks have been unloaded, and the status of the system. Daebel: "If fest tent mode is activated I know that the tank unloading at night was successful. Otherwise I try to get in touch with the tank crew and discuss the relevance of the trouble with them." If all else fails, the 62-year-old himself will check and troubleshoot before the beer tent opens, or else there'll be long faces among the visitors – and the tent operators. Every hour of system failure would amount to 12,000 unsold mugs equating to lost sales of about 130,000 euros.

3 sec.

is the average time it takes to fill a **mug** at the Oktoberfest.

13 %

of **Munich's power** demand flows to the Oktoberfest during the Wiesn weeks.

0

energy is required to cool the beer pipeline. The beer is delivered in refrigerated condition and keeps its temperature until being drawn from the tap.

In addition to all the beer, carnival rides at the Oktoberfest may cause visitors to feel like they're spinning (above). Contactless radar technology measures the fill level of the beer kegs (below)

In motion

Innovations in the course of time

Smart lines that changed the world

Practically all products today have their own identifier: a barcode. A beep and the checkout terminal knows the article's name, its origin, its price, its tax rate and more, thanks to some black and white bars. It all started in a supermarket in Ohio with a pack of chewing gum on June 26, 1974. It was the date on which the first ever code was scanned: the Big Beep so to speak. However, the idea was actually conceived a lot earlier: it's exactly 70 years old this year. In October 1949, the American students Joseph Woodland and Bernard Silver filed a patent for their printed "Morse code." It marked the birth of a new form of storing information. Without barcodes and their evolutions – the two-dimensional QR code being the most prominent one – today's retail, logistics and industrial world would not be able to operate: state-of-the-art connected warehouse systems that automatically pick and place goods; laboratories that reliably match urine and blood samples with the respective patients; consumers that print out their concert and flight tickets at home. Barcodes have been driving a myriad of developments and entire industries have changed as a result. However, it took a long time for all this to become possible – a period that stretched like chewing gum to use the same metaphor – because originally there were no optical scanners to read Woodland and Silver's bars. Their code only became useful when laser technology was introduced. Today, cash register scanners beep a billion times a day worldwide. Barcodes are omnipresent, yet nearly invisible: inconspicuous multi-talents that have become one of the most important tools of modern life.

» If you want to have good ideas you must have many ideas. Most of them will be wrong, and what you have to learn is which ones to throw away

Linus Pauling,
American chemist and two-time Nobel Prize winner

EAN-13 barcode example: composition and function

The EAN-13 code is a **E**uropean **A**rticle **N**umber with **13** digits. It is a one-dimensional code. The infrared or laser scanner distinguishes only between the reflection of the light on the spaces and the non-reflection on the thin bars. If the bar has a color, this stands for digital code 1, a space in between corresponds to the digital code 0. The scanner is able to detect if several bars (shown as white here in the layout, although they are typically black) or spaces are placed side by side and read them individually. The result of the optical reading of the bars including their digital conversion corresponds exactly to the depicted sequence of numbers. 12 digits represent the article number – divided into a base number 5 with the country and company and the article number 6. The 13th digit is a check digit 7 which is calculated from the 12 digits according to a formula. On the outside and in the middle, every code is always delimited by the same start and stop characters 2 4 and the delimiter 1. Encoded are 6 digits to the left and 6 digits to the right of the delimiter. Each digit 3 consists of 7 bits, i. e. 7 times 1 or 0 – but always exactly 2 bars and 2 spaces of varying thickness. On the left-hand side, the encoding of all digits begins with a space and on the right-hand side with a bar. Consequently, there are several charts for encoding the digits from 0 to 9. This ensures that the decoding is correct even when the barcode is read upside down.

Inner drive

The working world has seen constant change in hundreds of thousands of years. By contrast, this cannot be said for a major reason why we work. We'll reveal this much in advance: this reason is not found in our wallets.

By Volker Paulun

Our planet is not a place flowing with milk and honey. Humans have been going to work since time immemorial, if for no other reason than to satisfy their need for food – and have been doing so to this day. The first pre-historic jobs were those of hunters and gatherers. These activities serving the pure purpose of getting hold of food are commonly deemed to be humanity's oldest traditional economic system. Hunters, by the way, were also the first humans to use tools. The oldest hunting weapon found so far, a spear, is 300,000 years old.

The body's own reward

The realization that work not only satisfies our need for subsistence but can also make us happy is hundreds of thousands of years old, too, and can be explained by the fact that even the evolutionary ancestors of humans used to live in social groups. Only those who were socially accepted and belonged to a group were able to survive. Therefore, in the course of evolution, the human brain developed sensors enabling us to perceive the quality of social relationships, plus a network of nerve cells residing in the midbrain that's referred to as our motivation and reward system. When a human being – back than or today – experiences social recognition and appreciation the system releases a cocktail of happiness composed of ingredients like dopamine (an energy drug), oxytocin (a confidence and collaboration messenger substance) and internal opioids (messenger substances that make us feel good): a reward paid out by our brain.

These findings have led to important conclusions for today's working world, says the neurobiologist, physician and book author Prof. Dr. med. Joachim Bauer ("Arbeit – warum sie uns glücklich oder krank macht" – "Work – Why It Makes Us Happy Or Ill"): "People can only sustainably muster up commitment and motivation if they experience that what they do is perceived, acknowledged and appreciated. This doesn't mean at all that employees want to or should be pampered and constantly showered with praise. Even criticism can be perceived as a form of appreciation – provided it's justified and not communicated in disparaging ways. By the way, the necessity of 'being seen' not only applies to the job but also to activities in people's private lives."

> ***» Not what I have, but what I do is my kingdom***
>
> Thomas Carlyle,
> Scottish historian

Naturally, these mechanisms can also be undermined. The ancient Greeks and Romans for example did not value physical labor in any way. They only managed to evolve into advanced civilizations because slaves took care of all physically strenuous activities and thereby kept things running. Work and social life in Rome and Athens were by and large separate entities.

Upward mobility through work

This development only began to change in the Middle Ages. While the underprivileged and unfree rural population – which accounted for 90 percent of the total population in Europe at the time – perceived its unappreciated labor as a hardship and daily grind, craftsmen in the cities developed a rather self-confident attitude about their work. "Work

Up until and into the 19th century, forestry and farming were by far the most important labor and economic sector worldwide. Today, it accounts for 6.4 %, in countries like Germany and the United Kingdom for even less than 1 %

ennobles" became the slogan for upward mobility. Technical progress additionally spurred the growth of crafts. In larger medieval cities, there were as many as 100 different types of them. As blacksmiths, tailors or cobblers weren't able to eat the fruits of their labor and barter exchange became increasingly complicated the practice of paying money for work that has been preserved to this day became more and more prevalent. Naturally, the amount of money was also an expression of how much the work for which it was paid was valued and thus provided an additional stimulant to the reward system in the midbrain.

The example of the Fuggers, a family of former weavers, proves the truth of the old adage: A trade in hand finds gold in every land. From early 16th century Augsburg, Jakob Fugger ruled over a global merchant and banking empire "in which the sun never sets" as the saying went in those days. Expressed in today's terms, his assets purportedly amounted to 400 billion dollars, which would make him the richest person in history, even surpassing all the Bezos, Gates and Buffets of today's world. "Work ennobles" and the Fuggers were an extreme example of the veracity of this phrase. Other families of craftsmen managed to rise to the level of the middle class as well, and in doing so defined the importance and worth of work that's still valid today. Reformer Martin Luther spurred the diligent on by pithy statements: "Humans are born to work like birds are born to fly," he found, and even criticized the upper class's common indulgence in sweet idleness as a form of blasphemy: "Idleness is a sin against God's commandment, who has commanded us to work here."

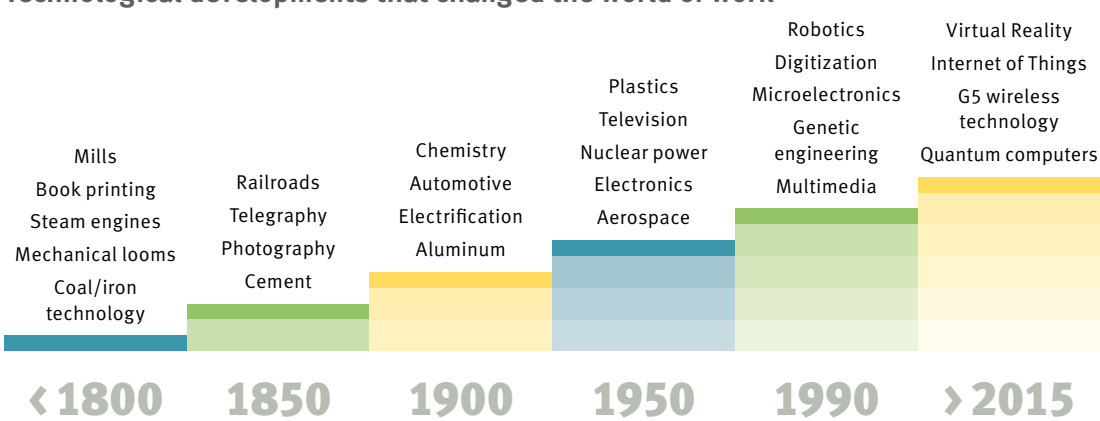
43

different smithing specializations have been identified in historic records about medieval Cologne. For instance, there were blacksmiths, farriers, and smiths that would forge nails, scissors, helmets, axes, boilers and pans. Bell-makers and pewterers, needle-, spur- and spear-makers were related crafts. Unsurprisingly, the last name Smith, derived from this metal-working occupation and said to have originated in England, and its various forms in other languages is ranked in eighth place of the most common last names worldwide.

The meaning of work

But let's return to the crafts once more, which to this day are deemed to be particularly fulfilling, as repeatedly confirmed by surveys. Creating something with one's own hands: from A to Z, something of lasting value. All this releases a rush of happiness cocktails from our reward center.

Technological developments that changed the world of work



In the middle of the 18th century, industrialization turned the working world inside out and spurred rapid economic growth from which the service sector profited as well. 72.1 % of the EU-wide working population is employed there and 23.7 % in increasingly automated manufacturing

However, in the middle of the 18th century, the happy hour in the brain begins to get lost in the wake of the industrialization of work. A unique piece of work turns into a product, mass-manufactured with the help of machines. At the beginning of the 20th century, the assembly line starts splitting production into monotonous work steps (see the following article). The previous satisfaction factor derived from the feeling of having created something now practically equals zero. However, there are two other reasons why industrialization dehumanizes work: one is that low-cost machine manufacturing cuts the ground from under the feet of many craftsmen and the other, even more important one is the precarious working conditions in the factories, especially in the early days of industrialization. Many people at that time moved from the country to the cities. In London alone, the population between 1800 and 1900 grew from one to nearly seven million. Rural people were almost magically attracted by the hope that their labor would be appreciated more in the new factories than on the estates of landlords. However, the sudden excess supply of labor caused the workers to become serfs of the factory owners.

Horrible working conditions, lousy pay and degrading living conditions soon drove people to go to the barricades: no wonder when a six-day 96-hour work week is not enough to feed a family. “The proletarians have nothing to lose but their chains. They have a world to win,” said Karl Marx’ in a rallying cry that was heard by the masses. All over the world, there were uprisings by labor movements as the proletariat was revolting against the moneyed and landed aristocracies.

Many things subsequently improved in the factories. However, increasing automation cost many of the jobs that had just been created – albeit they were more than offset by new ones. Today, in our post-industrial age of a service economy, 70 percent of all people in the countries now falsely labeled as industrial nations are working in the tertiary sector. At the moment, a fourth one, the information sector, is beginning to split off from the world of services.

The prehistoric human hunter has evolved into a data gatherer and now we’re no longer weaving fabrics but algorithms. Yet when you ask young people what drives and motivates them the answer is still the same as that of their forebears: social recognition and appreciation. Just like way back when we’d gather around a fire in front of a cave. Let’s drink to that with a happiness cocktail.

The conveyor belt of this printing plant resembles a confusing jumble

One thing after the other

More than a hundred years ago, the moving assembly line changed the manufacturing process: an awesome success story – and one that could soon be ending.

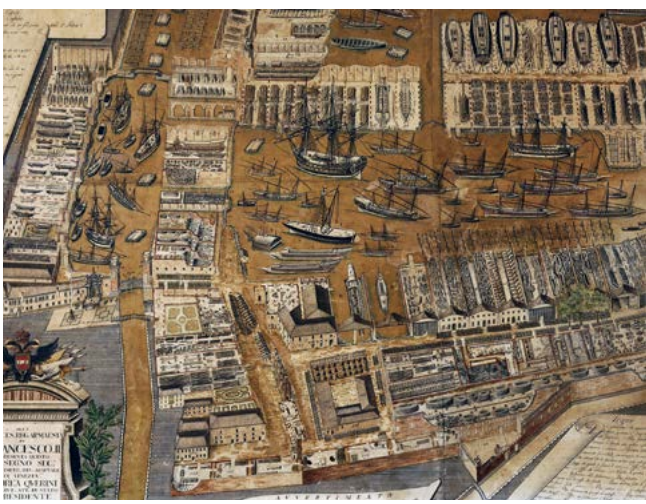
By Wiebke Brauer

They seemed to be unstoppable. Ever since they were invented, assembly lines have been running untiringly, shortening manufacturing cycles and material hauling distances. They've been saving time, space and money. In the course of decades, mass production on assembly lines has consistently been streamlined, standardized and perfected – and propelled industrialization into a new dimension. To achieve this, the lines have been moving along at an increasingly accelerated rhythm, diligently, unrelentingly, and dehumanizing work in the process, because workers became helping hands to machines that set the pace and forced them to do the same monotonous things over and over – day in day out. However, the splitting of work into individual segments didn't start with the modern assembly line but centuries earlier.

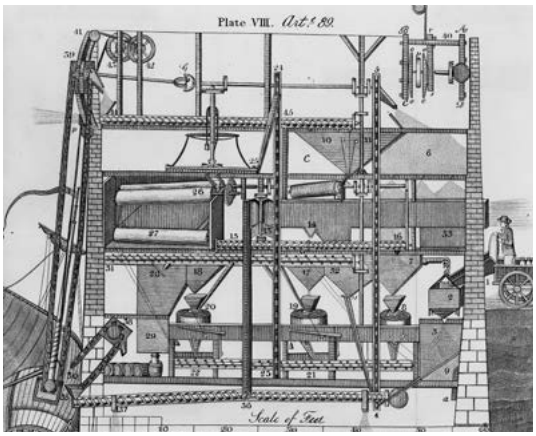
Assembly lines have been around for 500 years

The pilot run of mass production split into individual process steps did not start with Henry Ford as many of us might think, but much earlier – in the late 15th century at the Arsenale Novissimo shipyard in Venice. It's assumed that there the first ships were built by workers assembling standardized components in a form of line manufacturing. In this way, one sailboat per day was purportedly launched.

What an efficient system – and all of it without the help of wind or water mills, steam engines or electricity that would later give industrial manufacturing a real boost.

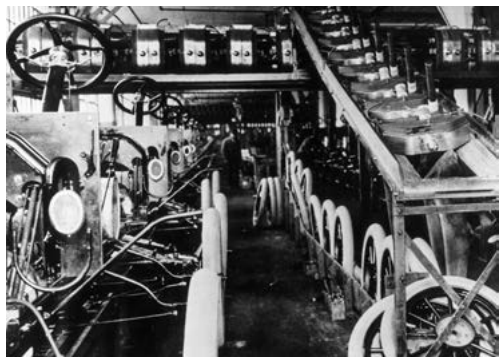


Ringing in the era of mass manufacturing in the 15th century: shipbuilding at the Venetian shipyard Arsenale Novissimo distributed to various stations



1787: This fully automated flower mill with a conveyor belt is regarded as the first milestone achievement in modern production technologies

Ford introduced the moving line into automobile production in 1913. Volvo stopped using it 60 years later – at least temporarily



But let's keep things in chronological order. In 1787, the American inventor and flour mill owner Oliver Evans used a conveyor belt to move whole grain and flour – as part of a fully automated flour mill. Evans' mill is regarded as the first milestone achievement in modern production technologies. His conveyor took cues from a water conveyance system dating to the Roman period, which tells us that this is an age-old concept. In 1833, a seamless conveyor system was rolled out in a factory for hardtack aka cabin bread near London. It's often referred to as the "first modern manufacturing line." Similar forms of manufacturing were known in the German baking industry as well, for instance at the Bahlsen biscuit factory where the first conveyor systems were used as far back as in 1905. To close the loop with the automotive industry: In 1901, the production of the Oldsmobile in Michigan was launched with the help of a moving belt system The vehicles were partially assembled on wooden racks and pulled to the next station.

Two sides of the Fordism coin

Even though Henry Ford ultimately just adapted existing manufacturing technologies to his needs he's deemed to be the "father of the assembly line." He'd adopted the idea from the world's largest meat factory, the Union Stock Yards in Chicago, where livestock were suspended from rotating conveyor chains called disassembly lines: disassembly vs. assembly. But be that as it may, on October 7, 1913, Ford's factory at Highland Park in Detroit started a pilot run of his first moving line for the production of the "Model T." Since then, this date has been regarded as the beginning of the moving line – and of Fordism – a synonym for soulless mass production decisively coined by Antonio Gramsci, a Marxist intellectual. Not to be forgotten in this context, though, is the fact that Henry Ford not only increased production eight-fold, but in doing so drastically reduced the price of his "Tin Lizzie" from 850 to 370 U.S. dollars. Suddenly larger parts of the population were able to afford their own four wheels, which rang in the era of personal mobility for everyone.

This was particularly true because the wages of the line workers clearly increased, too. In 1914,

Ford doubled the daily pay of his workers to five dollars and claimed that the Fordian principles had the potential of putting an end to poverty. In fact, a major portion of the workers' wages was spent on consumer goods, which served as a lubricant for the moving line of economic growth. However, Ford wasn't quite the benefactor he'd often tout himself as, because he only raised his workers' wages out of sheer necessity. In the early days of his line manufacturing operation, they'd run from his factory halls in droves. The demotivating monotony of line work caused personnel turnover to skyrocket to 90 percent. Peace and loyalty only moved in when Ford raised his workers' wages and introduced eight-hour days with a three-shift schedule.

However, a fundamental problem of assembly line work remained. "Bis repetita non placent" – repetitions are unpleasant, as the Roman poet Horace already knew in his day. Another point of criticism is the lack of satisfaction that comes from holistic creation. Because all you do is turn a screw or two, like Charlie Chaplin in his movie "Modern Times." Ford and those who copied him swept the issue under the money rug where it's been fermenting ever since.

In socio-critical Sweden, Volvo, in 1973, made a bold move against Fordism. At its Kalmar plant, the automaker announced its departure from assembly line work – not least driven by the looming threat of a strike wave as well as high personnel turnover and sickness absence rates. At the Uddevalla plant that was opened in 1989, the fulfilling principle of holistic creation was adopted as well: a team put together a complete car in the final assembly stage. Even though the productivity of both plants was deemed to be competitive for a long time, both were shut down. Volvo explained the decision by saying that without repetitive work higher levels of automation could not be achieved at the plants and that, consequently, they no longer had a viable economic future. The irony of this industrial story: In 1999, Ford swallowed Volvo's troubled passenger car division. Today, Volvo is a Chinese company.

Perfect monotony machines

Robots are perfectly suited for automating repetitive work. "Robot" is the Czech word for "servitude" and "drudgery." The automatic toiler doesn't mind monotony, goes about its work without stopping or complaining, but with efficiency, precision and speed, and does so 24/7: the perfect partner for assembly lines. In 1961, the first industrial robot, the Unimate weighing 1.8 metric tons (2.0 short tons), installed die-cast elements on car doors at a General Motors facility.

7.2 km (4.47 mi)

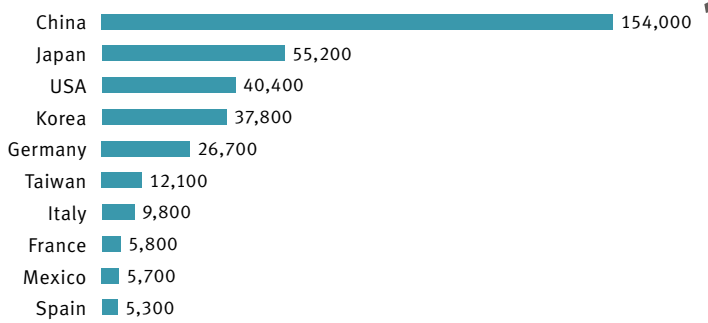
is the length of the world's longest conveyor belt. At a dizzying height in Barroso (Brazil), it moves 1,500 metric tons (1,650 short tons) of calcium silicate brick per hour above trees, hills and roads. The humongous belt replaces 40 trucks per hour.

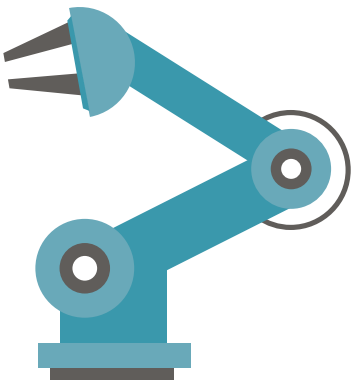
Robots and humans hand in hand

Today (not only) car factories are full of robots. Let's take SEAT's parent plant in Martorell near Barcelona, for example, where cars were still painted by hand up until the 1970s. Today, 84 robots apply the paint in a spray booth. More than 2,000 robots are employed in the metal shop and 125 autonomous robots in the assembly hall. Although that's an awesome number in total they're still a minority because more than 7,000 human colleagues are working side by side with them.

The 10 biggest robotics markets

Source: World Robotics Report 2019





80,000

electronic components per hour, from simple resistors to highly integrated processors, are shot by the fully automated "chip shooter" with thousandth of a millimeter accuracy onto printed circuit boards rushing by on a moving line. The system produced in Japan is deemed to be the fastest assembly machine in the world.

Side by side is a phrase that can increasingly be taken literally. While industrial robots used to be confined to cages, they're now allowed to work in the context of Human-Robot Collaboration (HRC). The electrical colleagues of humans have also received a new name. The collaborating robots that increasingly often can be seen right next to the conventional line worker are called cobots. Their purpose is not to replace humans but to relieve them of monotonous and physically strenuous jobs.

The fact that hard times are in store for the assembly line at least in automobile production is attributable to the increasing customization of this mass product. Henry Ford's witty remark that a customer can have a car painted in any color as long as it's black has long ceased to be relevant. Thanks to endless lists of options even bread-and-butter cars can be configured to become one-of-a-kind. Such levels of customization cause even the best assembly line to stall. A modular, intelligently controlled assembly process using mobile robots instead of a moving line to deliver the material to the assembly stations just in time can handle this in much better ways.

In the light of such developments, the notion that, of all things, the customer's wish for greater variety might put a stop to the monotony of the assembly line – at least in automotive manufacturing – is indeed intriguing.

The author

To finance her first motorcycle, Hamburg journalist **Wiebke Brauer** (ramp, ADAC Motorwelt, spiegel.de and other publications) spent several weeks as an assembly line worker: a learning experience, no doubt, but she found that she had a greater knack for writing.

Expert know-how

One of Schaeffler's fortes is the company's production know-how developed in more than 120 years.

A perfect example: UniAir. The idea of the fully variable valve control system was conceived at the Fiat Development Center RCF. However, the expertise in developing the system to market level, industrialization and manufacturing was lacking there. Schaeffler's experts have been contributing it since 2009.

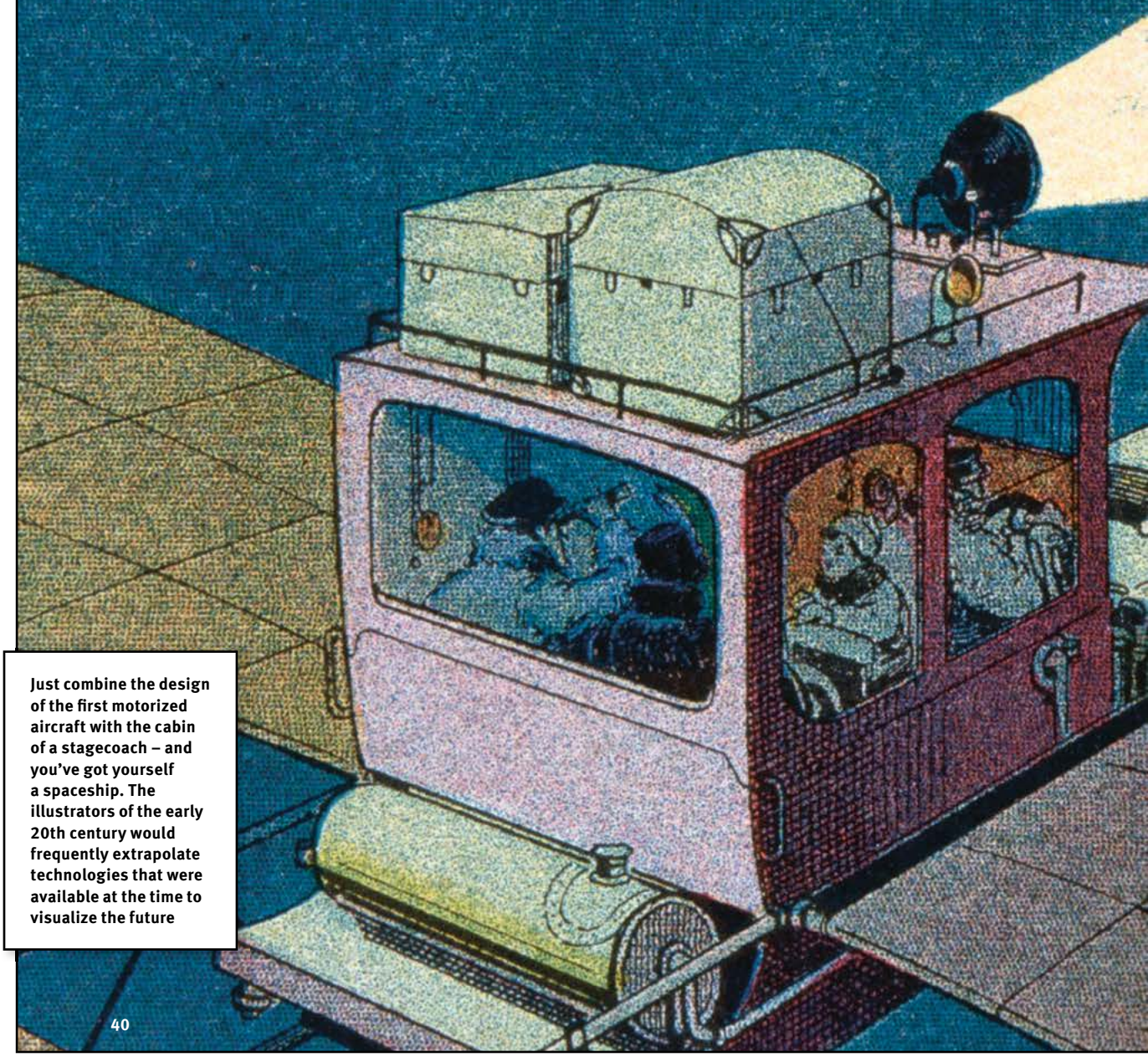
The Schaeffler Group supplies high-quality products to more than 60 sectors in total – with a commitment to "zero defects." In addition to a standardized worldwide quality management system, Schaeffler relies on close collaboration between product and production specialists in this context.

Special-purpose machinery has been one of the traditional fortes of the Group (see also page 68). If Schaeffler's exacting expectations cannot be met by a production machine that's available on the market the machine will be developed and produced in-house. No matter whether a product is made in-house or purchased, Schaeffler has a tradition of incorporating state-of-the art technologies in its manufacturing operations. Included already or planned for the near future are additive manufacturing (including 3D printing etc.), lightweight design, work with digital twins, collaborative robots (cobots) and autonomous production. However, new technologies don't necessarily have to replace time-tested ones. According to Schaeffler's experience, a combination of both may well prove to be the best solution.

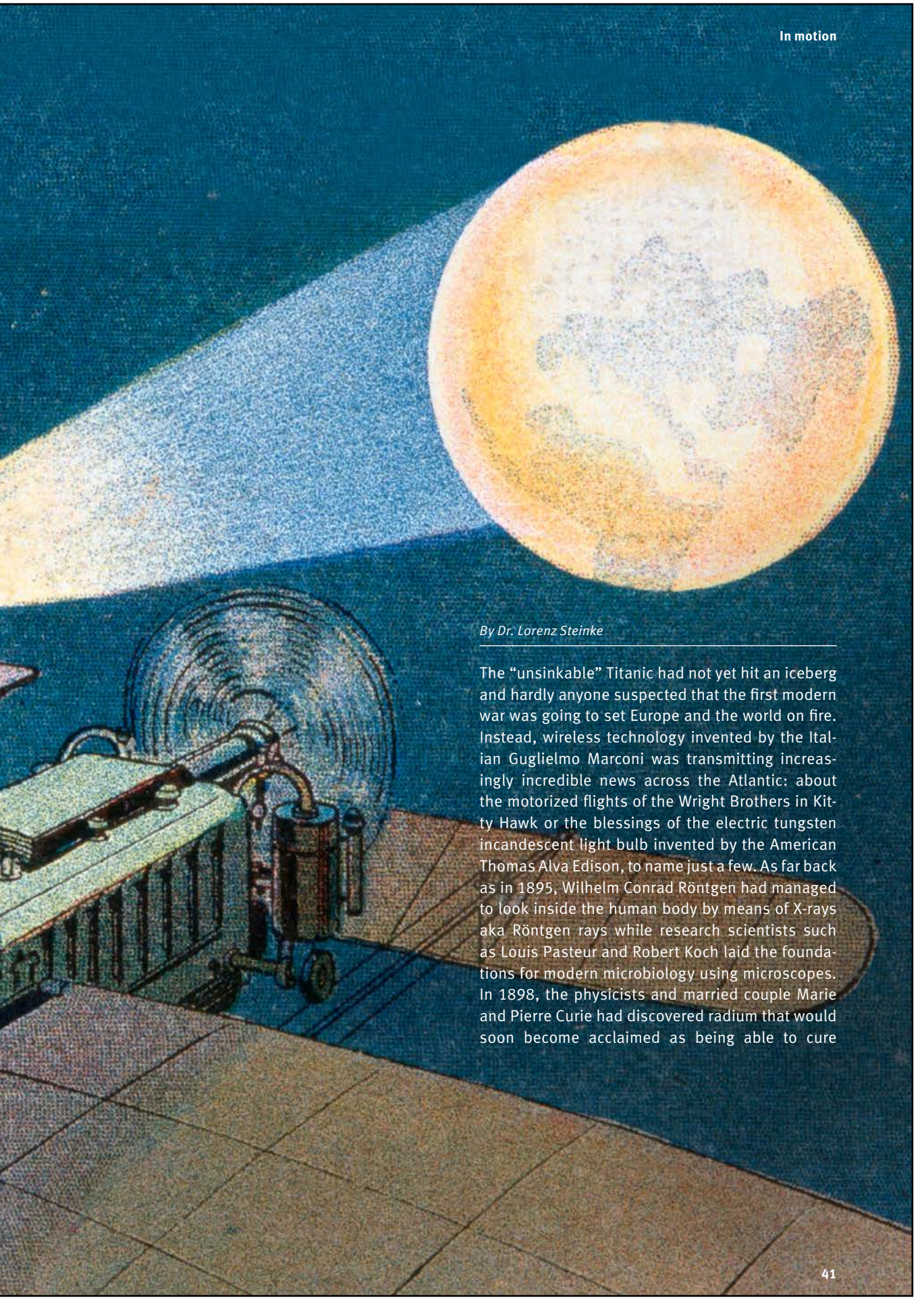
Seven decades of "made by Schaeffler" manufacturing excellence: quality inspection and control in 1951, automatic needle production in 1960, clutch manufacturing in the early 1990s and Industry 4.0 in the "Factory for tomorrow" at Schaeffler's site in Taicang, China

Grandpa's Journey to the Moon

The future was never brighter and enthusiasm for technology never greater than during the brief period between the eve of the 20th century and the outbreak of the First World War: Electricity, radioactivity, the first motorized flight, radio telegraphy – nothing seemed impossible for human ingenuity. Even the working world was soon going to look a lot different than it used to …



Just combine the design of the first motorized aircraft with the cabin of a stagecoach – and you've got yourself a spaceship. The illustrators of the early 20th century would frequently extrapolate technologies that were available at the time to visualize the future



By Dr. Lorenz Steinke

The “unsinkable” Titanic had not yet hit an iceberg and hardly anyone suspected that the first modern war was going to set Europe and the world on fire. Instead, wireless technology invented by the Italian Guglielmo Marconi was transmitting increasingly incredible news across the Atlantic: about the motorized flights of the Wright Brothers in Kitty Hawk or the blessings of the electric tungsten incandescent light bulb invented by the American Thomas Alva Edison, to name just a few. As far back as in 1895, Wilhelm Conrad Röntgen had managed to look inside the human body by means of X-rays aka Röntgen rays while research scientists such as Louis Pasteur and Robert Koch laid the foundations for modern microbiology using microscopes. In 1898, the physicists and married couple Marie and Pierre Curie had discovered radium that would soon become acclaimed as being able to cure

virtually any disease due to its beneficial radiation and – in sufficiently high dosage – even put an end to aging and death. Meanwhile, German cavalry general Count Ferdinand von Zeppelin lent wings to the high-powered dreams of a whole nation with his rigid airships made of cotton, aluminum and the intestines of cattle. With that, the force of gravity seemed to have been overcome once and for all.

Some utopian dreams became reality

» If you want to read the future you have to scroll in the past

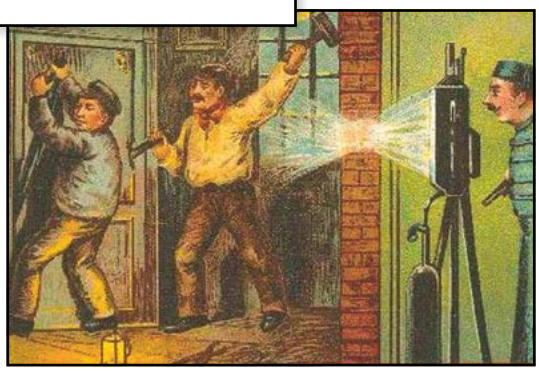
André Malraux, French writer (1901–1976)

In keeping with the euphoria of the times, scientists and the still young genre of science fiction novels, as well as the illustrators of the collectible cards added to chocolate boxes that were highly popular at the time, painted a bright picture of the year 2000. The Berlin-based cocoa factory Hildebrand (subsequently known for its caffeinated Scho-Ka-Kola chocolate brand) saw law enforcement officers of the future **hunting down criminals using portable X-ray devices to peek through walls.** Today, reality has long caught up with such fantasies. The Hamburg Customs Authority, for instance, has been X-raying shipping containers to put a stop to the game of criminal smugglers since 1996. The first 20 years reflect the following statistics: in total, more than 1.5 billion untaxed cigarettes, 2,700 weapons and ammunition, 38,000 kilograms (83,770 lb) of marihuana, 13,200 kilograms (29,000 lb) of hash, and 4,600 kilograms (10.140 lb) of cocaine were confiscated – identified by just one stationary system. The observation of suspects through walls as shown in the pictures on little chocolate cards has been possible for a long time, too – thanks to sensitive thermal imaging cameras.

But let's go back to the utopian dreams of the past: **Fire fighters** depicted on a French postcard series (En L'An 2000) **equipped with bat wings** would fly to the scene of the blaze, while **border patrol officers accelerated by propellers** on their back would hunt down smugglers. These visions have become reality, too. Dubai equips its fire fighters with jetpacks designed to enable them to rescue people from burning skyscrapers. The emirate's police force is also supposed to become airborne, by means of hoverboards, while fighting crime with unmanned aerial vehicles aka drones has already become routine practice.

In the area of mobility, utopian thinkers have demonstrated visionary powers as well – even though some of their ideas got stuck in the world of fantasy: Back in those days, global distances had shrunk into short commutes, a suspended monorail train would provide a daily shuttle service for business travelers from Berlin to Cameroon. Those having to cross the Atlantic on business would take the subsea **"whale bus"** or the practical **maritime railroad** across water and land, whose trains seamlessly glided from the waves onto the train tracks. And people with an even greater zest for travel would hop on a motorized flying taxi to the Moon and back (Chocolaterie Lombart, Paris, 1912) at night.

Bleak prospects for perps: police officers use X-ray vision …



… and border patrols surveil the airspace

High-rise buildings suddenly grow skyward – and fire fighters follow suit with wings

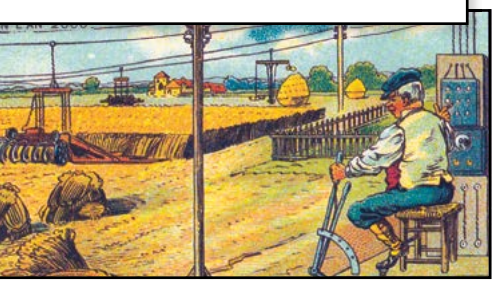
Seafaring visions: amphibious switching between elements using maritime trains and underwater whale buses to cross the Atlantic

Meanwhile the farmer of the year 2000, while sitting on his porch, would direct an armada of **harvesting machines through his fields using the toggles of a remote control device.** In this case, autonomous agricultural machines and robotic farm hands have long become reality, too. Another example of a vision-turned-reality is the tailor next-door producing a custom suit from a **steam-powered 3D printer** with a flick of the wrist. By contrast, the vision of a conductor directing the performance of a **robotic orchestra** has still remained a utopian idea. And will a **robot ever replace a barber?** If so, then it will no doubt differ from the illustration in the French postcard series where a barber was operating an early forebear of a modern industrial robot that would almost tenderly move the shaving brush and razor across the cheeks of trusting clients. However, this whole operation seems far more complicated than the barber having done the job himself. Or could it perhaps be that this card doesn't mean to depict the anticipation of a desirable future at all, but questions whether it makes sense to use a machine?

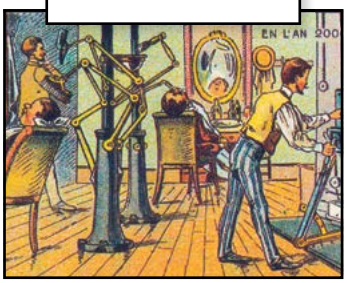
Visionary acceleration

Common to all the utopian ideas of those days is an awesome zest for motion and acceleration that define the working world of an imagined future anticipated by farsighted visionaries. While just 70 years earlier the first railroads had still been rejected in Europe for fear that their awesome speed of 20 and more miles per hour might harm the

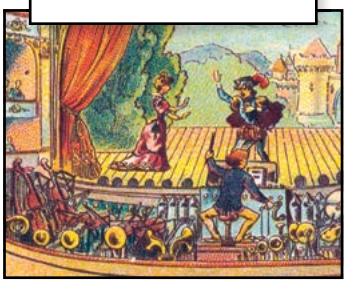
Machine maestros on a farm ...

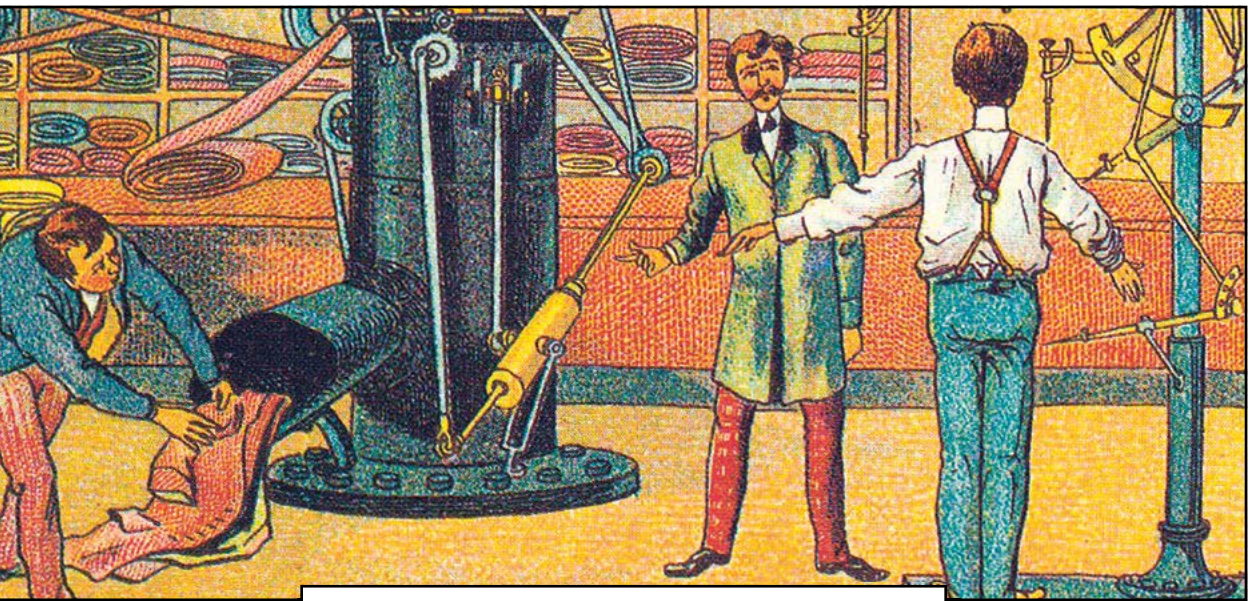


... at a barber shop ...



... and in an orchestra pit





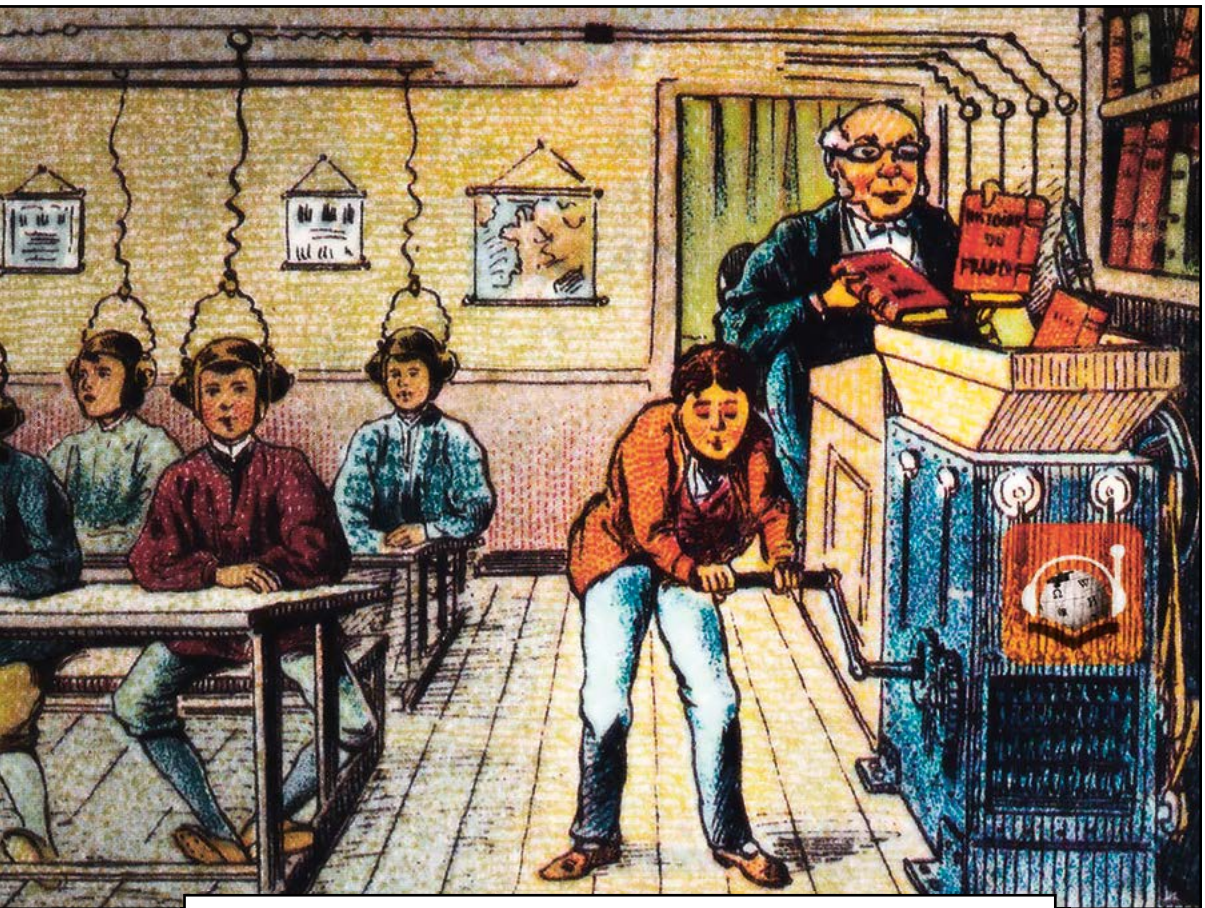
100 years ahead of 3D printing: the steam-powered custom tailor

lungs of passengers and traumatize innocent bystanders on neighboring roads, speed is now seen as a positive across the board. Even school has become a high-speed learning factory in which the teacher throws stacks of books into the hopper of a **learning machine** that hammers the writings of Horace and Euclid into the students' brains in record time using a flow of electrons.

In spite of a few amusing misses, the far-sighted accuracy with which the illustrators who created these utopian pictures visualized the future is amazing. Or vice versa: the accuracy with which progress has fulfilled the hopes and expectations of the people who lived one hundred years ago.

The author

Journalist and historian **Dr. Lorenz Steinke** has been exploring the technological visions from the turn of the century for years. The imagination and bold belief in progress prevailing in that era, when fear of tomorrow was unknown and daredevil pilots made their first attempts of conquering the skies in rickety contraptions, holds a particular fascination for him.



Who needs Google when a machine electronically funnels world knowledge into your brain

Here and now

Living with progress

Monocoque
Specification Spark chassis featuring a fiber composite construction of carbon fibers with an aluminum honeycomb, tested according to the strict FIA crash and safety standards

Wrap
The Audi e-tron FE06 is wrapped with film, as is common practice in racing. The livery changes each season. The Schaeffler green has been a constant for six years

Track layout sticker
Each turn has a number assigned to it; sections are divided into colors as a basis for communication between the drivers and teams

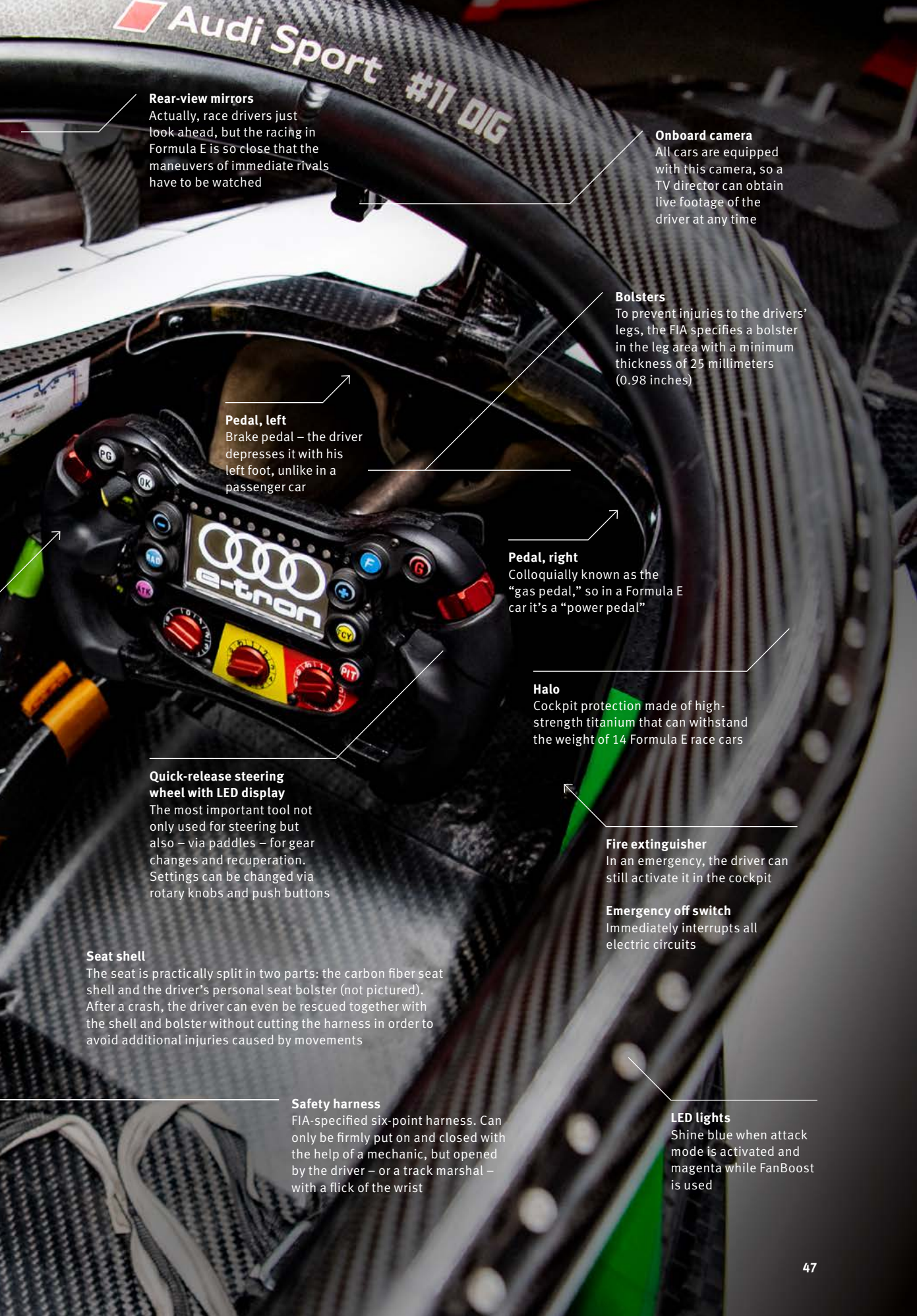
Nametag
In addition to the personal numbers assigned to their cars (di Grassi #11, Abt #66), there are stickers with the drivers' last names and national flags

Audi Schaeffler MGU04
Motor-generator unit jointly developed by Audi and Schaeffler with a maximum output of 250 kW

Main switch
for on and off

The Formula E cockpit workplace

Cramped, hard, uncomfortable, but fast-paced and always provided in a different big city: The workplace in the Audi e-tron FE06 of the Audi Sport ABT Schaeffler team is one of the most spectacular and coveted ones of all. The two that are available have been awarded for the sixth year to Lucas di Grassi and Daniel Abt. They must be able to leave it within a maximum of seven seconds – this time is subject to checks. And because "driving by the seat of their pants" is the alpha and the omega for all racers, they all bring their own "office chairs" – a custom-molded seat bolster (not pictured) – when climbing into the car to ensure that the connection between the car and the track feels as authentic as possible.



Rear-view mirrors
Actually, race drivers just look ahead, but the racing in Formula E is so close that the maneuvers of immediate rivals have to be watched

Onboard camera
All cars are equipped with this camera, so a TV director can obtain live footage of the driver at any time

Bolsters
To prevent injuries to the drivers' legs, the FIA specifies a bolster in the leg area with a minimum thickness of 25 millimeters (0.98 inches)

Pedal, left
Brake pedal – the driver depresses it with his left foot, unlike in a passenger car

Pedal, right
Colloquially known as the "gas pedal," so in a Formula E car it's a "power pedal"

Halo
Cockpit protection made of high-strength titanium that can withstand the weight of 14 Formula E race cars

Quick-release steering wheel with LED display
The most important tool not only used for steering but also – via paddles – for gear changes and recuperation. Settings can be changed via rotary knobs and push buttons

Fire extinguisher
In an emergency, the driver can still activate it in the cockpit

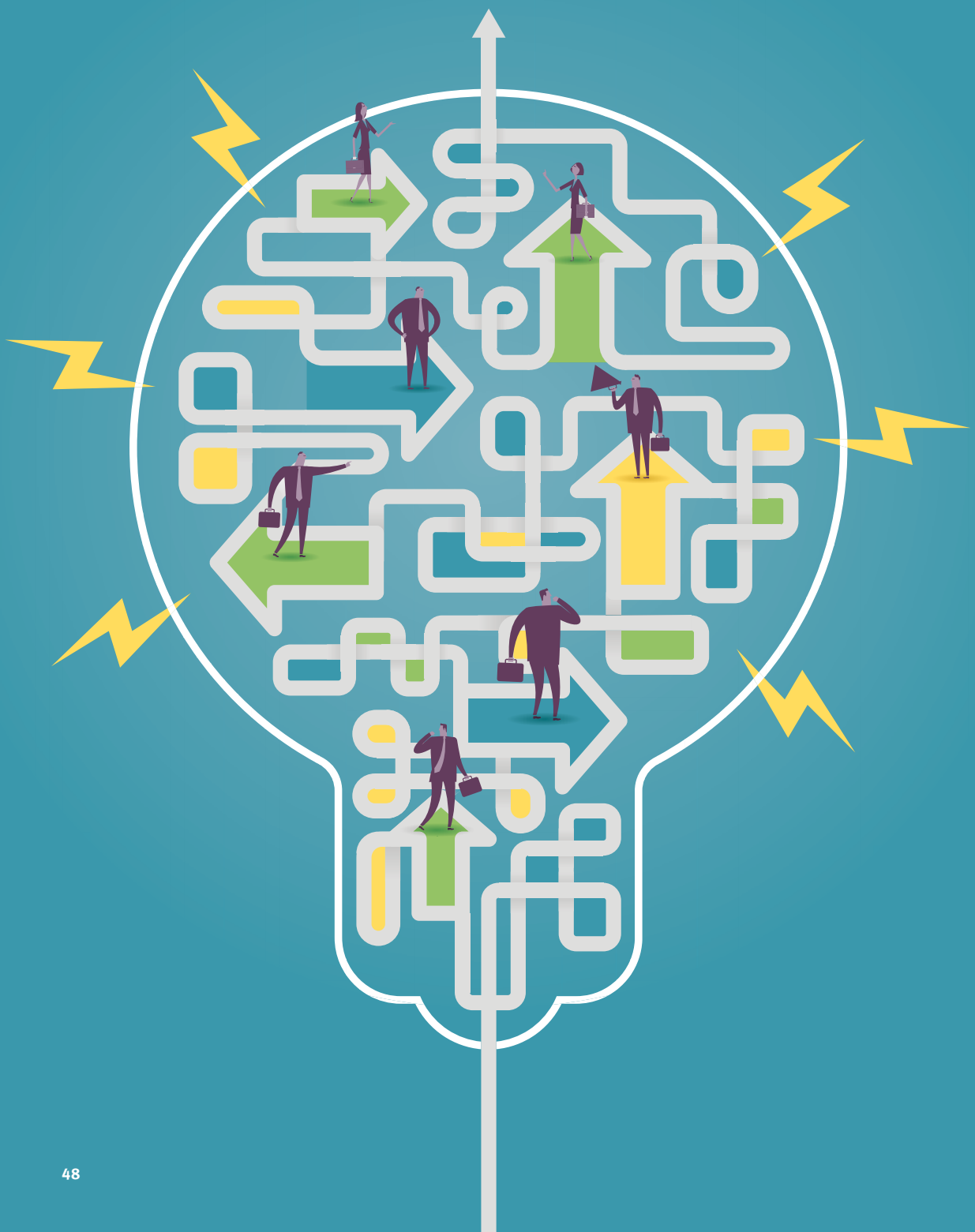
Emergency off switch
Immediately interrupts all electric circuits

Seat shell
The seat is practically split in two parts: the carbon fiber seat shell and the driver's personal seat bolster (not pictured). After a crash, the driver can even be rescued together with the shell and bolster without cutting the harness in order to avoid additional injuries caused by movements

Safety harness
FIA-specified six-point harness. Can only be firmly put on and closed with the help of a mechanic, but opened by the driver – or a track marshal – with a flick of the wrist

LED lights
Shine blue when attack mode is activated and magenta while FanBoost is used

Rethinking the world of work



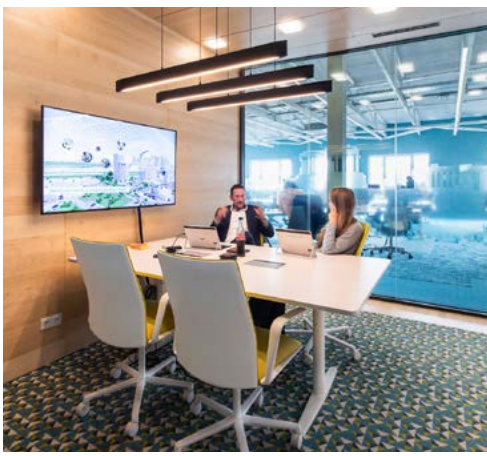
Developing increasingly sophisticated products at a continually accelerating pace – this can only be achieved with lean, agile organizational structures. "New Work" is the name of the new fitness formula for companies.

By Volker Paulun and Dr. Lorenz Steinke

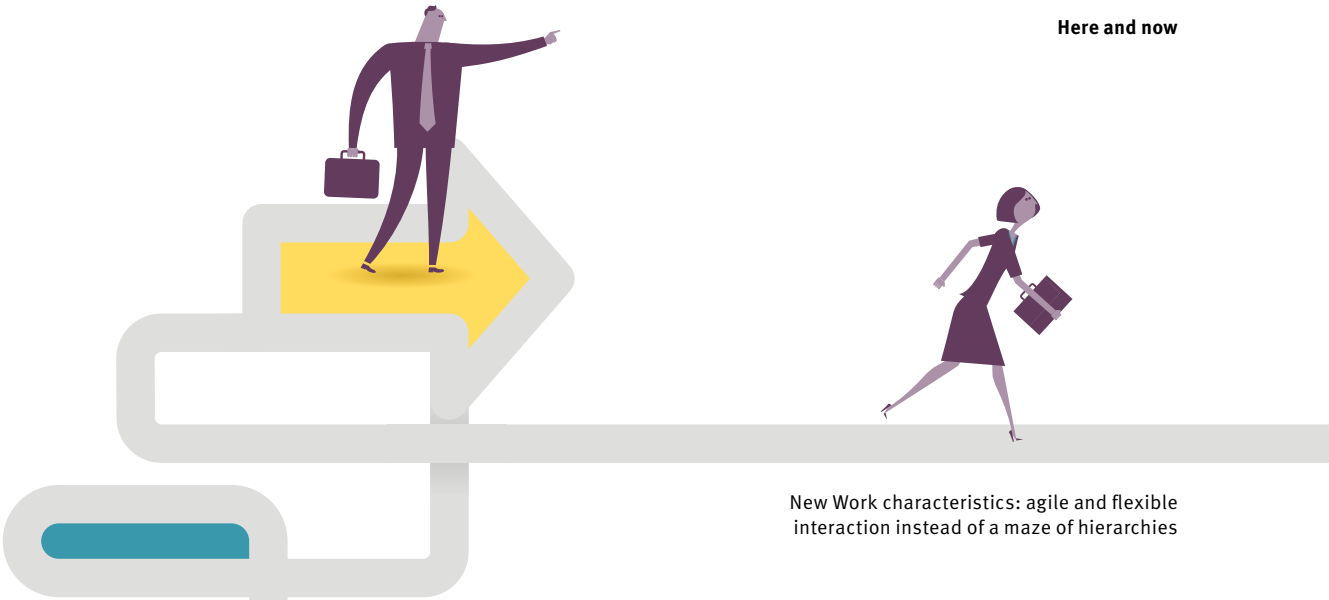
Bodo Janssen is shocked. In 2010, the CEO of the family-owned hotel and holiday resort operator Upstalsboom initiates a survey among his 650 employees. The painful feedback: "We need a different boss." So, what does the boss do who has just suffered such blatant rejection? He beats feet – heading for a monastery. Guided by Benedictine monk and management trainer Anselm Grün (see also tomorrow 01/2017), Janssen develops a new view of many things. As a result, his employees get a new boss, who has the same name and looks the same as the previous one but returns with an all-new company culture in his travel bags. Henceforth he grants every one of his employees the freedom to pursue their personal development and to dedicate themselves to things that are important to them – in self-organized teams – along the lines of Pericles: "The secret to happiness is freedom. And the secret to freedom is courage." Janssen mustered precisely this kind of courage and among the rewards he reaped was a boost of success in business: the sickness absence rate dropped from eight to three percent, both employee and customer satisfaction significantly increased and sales doubled in the first three years following his change in philosophy.

New Work is actually old school

The "Upstalsboom way" is a good example of a successful implementation of New Work because it's largely congruent with two basic ideas of Austrian-American philosopher Frithjof Bergmann, who coined the term New Work in the mid-nineteen-seventies. Now nearly 90 years old, Bergmann found at the time that, thanks to technological innovations and continuous productivity increases, the working world provided more room for the individual to pursue his or her personal wishes and concepts of how to live one's life. Work, he demands, should be organized in a way so that it's not forced upon people. Instead, everyone should do the work they really, really want. Bergmann's second idea is that information technology makes hierarchies superfluous and replaces them by more efficient and faster horizontal structures.



Open work spaces for collaborative teamwork, quiet zones for focused work and flexible workshop areas: the space utilization concept of Schaeffler's Digital Transformation Center (DTC) is fully aligned with the needs of digital, creative and agile ways of working



New Work characteristics: agile and flexible interaction instead of a maze of hierarchies

Hence the idea of self-organized teams with self-determined team members, which – driven by technology – was adopted by the software industry in the nineteen-nineties. Multi-tiered hierarchies, complex reporting systems and controlling practices setting the pace: All these factors had been slowing projects down so much that software was often obsolete before it even reached the client. In addition, many applications were never finished because bugs detected during their development stage were not reported to higher levels of management, resulting in ever new completion deadlines that employees at the operating level knew could not be met. Market success returned only when companies switched to a more open organizational culture and flatter hierarchies.

Corporations implement New Work – with success

Steadily growing pressure to innovate, shorter and shorter product cycles, and manufacturing and development technologies are the reason why the ideas of New Work flourish also in major corporations that have traditionally tended to be rigid. Let's take Siemens for example. There the project of a new factory building had tied itself in knots – ultimately to the point of total standstill – due to hierarchies, control mechanisms and detailed planning. Siemens' project specialists Sabine Kluge, Ronny Grossjohann and Dr. Robert Harms initiated a radical change toward self-organized agile ways of working, in which the project members became real entrepreneurs and project owners. The resulting factory surpassed all expectations, according to Siemens.

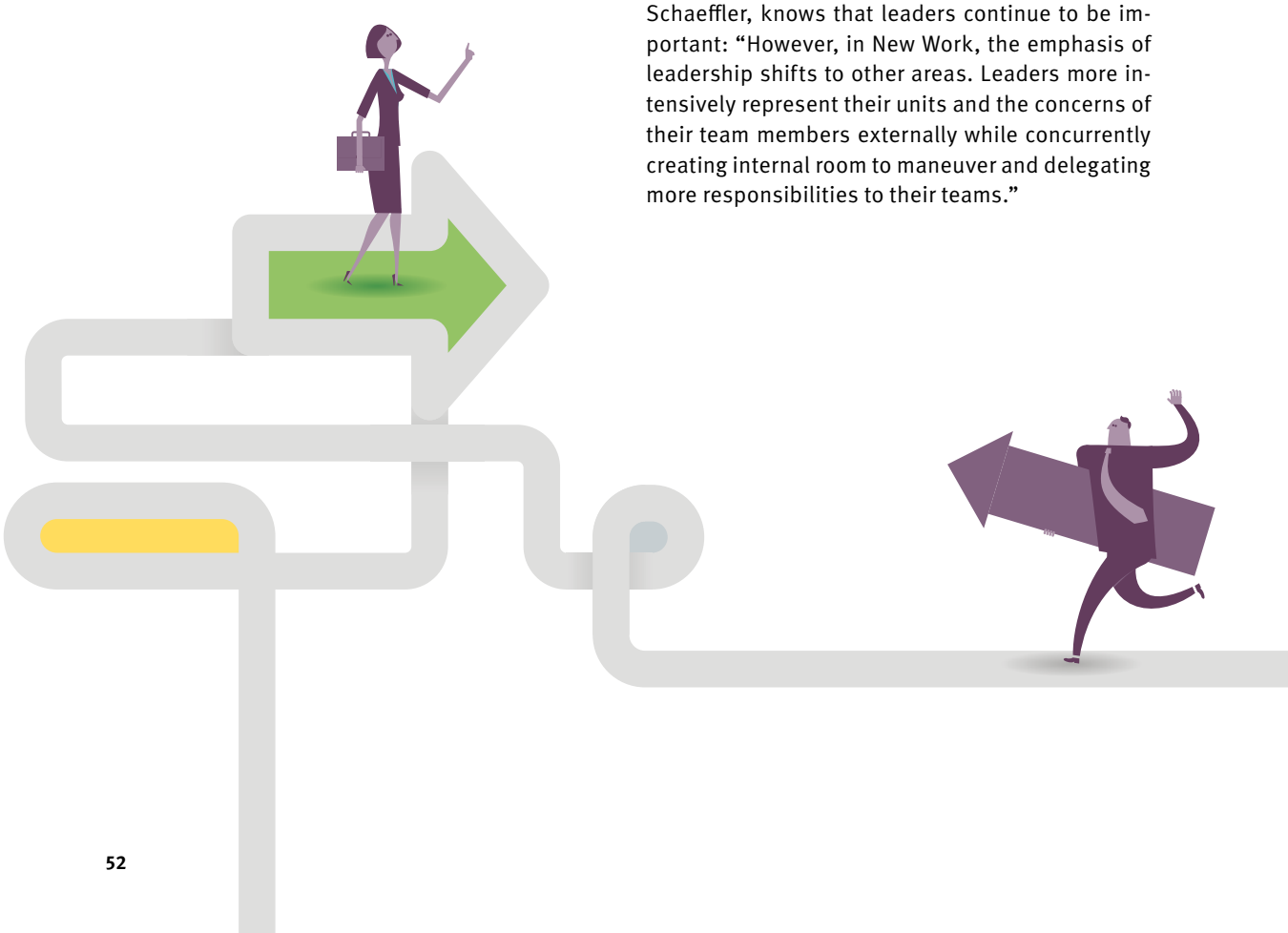
Fast, agile and highly effective teams with members who think like entrepreneurs: these so-called intrapreneurs are the transformation vanguard of major corporations on the road toward new agility. Automotive and industrial supplier Schaeffler has long recognized the effectiveness of such small entrepreneurial units, too. The Bio-Hybrid is a case in point. The idea of closing the gap between bicycles and electric microcars by a four-wheel e-bike was initially driven in-house

by a dedicated project team and has since evolved into an independent start-up company. Obviously, the transition to New Work, which is a fundamental one, has not been happening on its own at Schaeffler either. Sandra Köllner, Director of New Work, reports: “Of course, there were some skeptical voices at first. It’s important that all the stakeholders openly discuss how processes and structures change. However, following a rollout phase, New Work met with very positive response at our pilot locations.” The first unit Schaeffler reorganized according to new New Work standards was special-purpose machinery engineering (see also page 68) at the Frauenaurach location. The department moved into its redesigned offices in June 2017. “Agile collaboration among teams called for a new, open space concept,” Schaeffler’s expert Andreas Possel explains. The redesign was also a New Work project, in which employees participated as change agents. At the Schweinfurt location, in the Digital Transformation Center (DTC) in Herzogenaurach, and in the two buildings of the so-called Air Campus in Nuremberg that is home to IT staff, process specialists and logisticians from Schaeffler, New Work principles have been implemented as well.

That such pilot projects can also provide important impetus to other large corporations in the context of making the entire organization more agile is a conviction that Dr. Thorsten Lambertus, a management & engineering professional and intrapreneur expert at Fraunhofer Venture, shares as well. In an article published by the trade magazine “automotiveIT,” he said, “You have to start taking specific action somewhere to encourage the formation of germ cells that can serve as role models for others.”

It’s the teams that matter

Self-determination and self-organization as proclaimed by the New Work concept entails a high level of responsibility – which has to be given up on the one side and accepted on the other. At Upstalsboom, this give-and-take has been working well, not least because the company’s recalibrated CEO Bodo Janssen prudently moderates the process. Andreas Possel, Head of HR Strategy at Schaeffler, knows that leaders continue to be important: “However, in New Work, the emphasis of leadership shifts to other areas. Leaders more intensively represent their units and the concerns of their team members externally while concurrently creating internal room to maneuver and delegating more responsibilities to their teams.”



Obviously, teams need to have high levels of empowerment and diverse skill sets to pick up the ball of responsibility and run with it. In a two-year million-dollar project that involved 180+ teams, Google with the help of psychologists, statisticians, sociologists and engineers investigated what makes a project team work most effectively. Five key dynamics emerged from the research:

1. Psychological safety: Can we take risks on this team without feeling insecure or embarrassed?

2. Dependability: Can we count on each other to do high-quality work on time?

3. Structure & clarity: Are goals, roles and execution plans on our team clear?

4. Meaning of work: Are we working on something that is personally important for each of us?

5. Impact of work: Do we fundamentally believe that the work we're doing matters?

The end is more important than the means

Outcomes are what matters most in modern teamwork. The number of hours spent at the office or the number of miles traveled on company business are becoming less and less important as proof of professional commitment. Work separates itself from presence. It's totally immaterial whether employees use telecommuting arrangements because they might like to pick up their kids from the childcare center in the afternoon or spend some hours sitting in the sun at the local park – with a notebook on their lap. Output is the only thing that counts. Obviously, for large corporations, in which many different camps clinging to traditional concepts have to be aligned, it's especially difficult to roll

Sharing and getting ahead

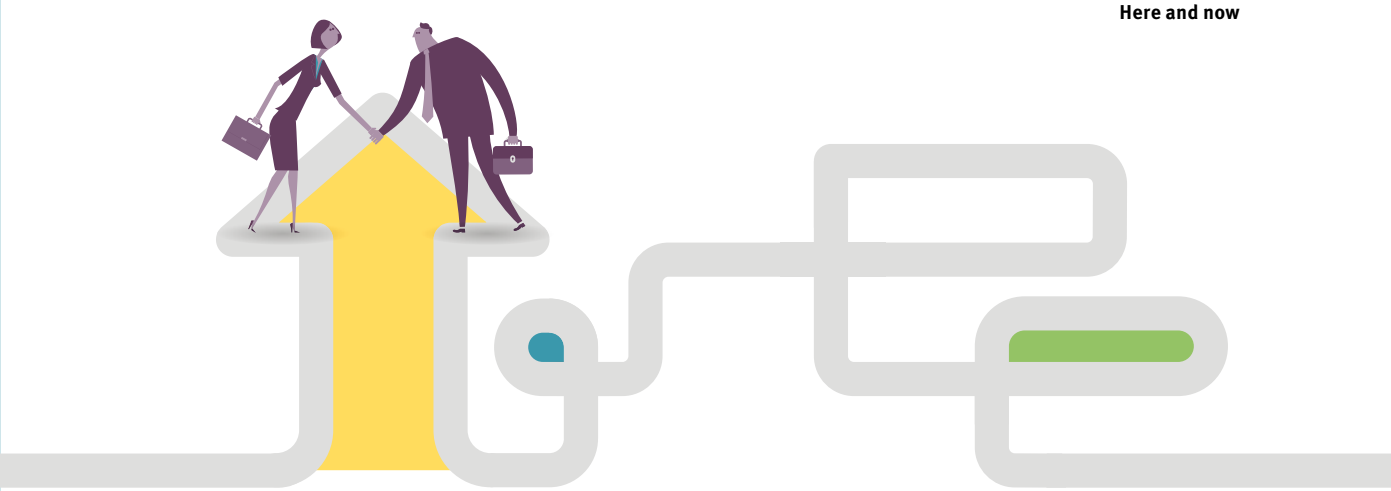
Continually developing one's strengths? Broadening one's professional and personal profile while adding greater depth to one's network?

These are the goals of Schaeffler's mentoring program, which is special in that all employees can now participate and pursue their further development within the company either as an experienced mentor or as mentee with a zest for knowledge. A survey by the career portal "Monster" validates Schaeffler's experiences.

HR expert Thomas Zahay from Monster comments: "I'm not surprised to see that 47 percent of Gen Y (birth years 1980–1999) think about mentors and that 22 percent would like to have a mentor. This generation is used to receiving feedback not just once a year, but engaging in constant exchange with their leaders and peers. Considering the special role of parents as advisers, it comes as no surprise that millennials like the idea of being supported by experienced colleagues." Zahay would welcome programs like Schaeffler's to catch on. "At the moment, only 23 percent have a mentor that helps them in their further personal development," he says. Clearly, there's room for improvement in this area.

» THOSE WHO ARE CRAZY ENOUGH TO THINK THEY CAN CHANGE THE WORLD USUALLY DO

Steve Jobs,
founder of Apple



out such flexible work scheduling and employment models. New Work experts also frequently use the portmanteau "flexicurity" for a concept of labor market policy that's designed to enable the necessary flexibility of work while guaranteeing job security. Breaking through entrenched ways of thinking also requires courage plus plenty of persuading.

At the Berlin-based innovation consultancy Partake, the firm's founder, Dr. Hans-Jürgen Erbeldinger, is already granting his staff an extremely large degree of freedom: from day one, all employees can personally select the topics they'd like to work on and may even initiate projects of their own. The only condition is that they find peers to support their ideas. If they manage to do so, this is regarded as an adequate quality characteristic to pursue and drive any idea, no matter what kind. If not, the project is discontinued.

Obviously, such a high degree of freedom cannot be implemented in all companies as easily as in a creative agency – plus it doesn't find favor with all employees. It's not uncommon for project responsibility to be perceived as a burden. Some people reject the concept of proposing ideas and job content within the team or to higher organizational levels. They prefer executing the boss's decisions.

However, modern job concepts are highly popular particularly with career starters. Flexible work schedules, higher project responsibility, the opportunity to regularly work from home or to take sabbaticals: Candidates often address these aspects as early as in job interviews and may even aggressively insist on them. 75 percent of young employees belonging to "Generation Z" (birth year 1997 and younger) are eager to assume diverse roles, according to a McKinsey report, knowing full well that this kind of job hopping requires life-long learning, which is another idea proposed by New Work mastermind Bergmann. Only continuous education and training empowers people to flexibly adjust to new working conditions and demands.

New Work makes employers "sexy"

Apropos career starters, on the job market, an agile organizational structure with a flat hierarchy and an open innovation culture has the effect of a neon sign on young people who want to make a difference. This aspect should not be underrated because in times of skills shortage especially graduates of STEM programs can increasingly pick and choose their employers. Consequently, companies have to come up with quite a bit to attract the best brains.

An appealing workspace environment is one of these attractions and New Work provides guidance in this area, too. Other important criteria include an IT structure that's as open as possible and allows all stakeholders to access all data. Seeing, feeling, thinking, talking, acting: everything will be different in the new professional world or as New Work inventor Frithjof Bergmann puts it: "New Work means that we can experience and perceive work in completely different ways than before and have to prepare for this fundamental difference."


SCANIA
ABL
ABL
Order: 05723 confirmed
Destination: Area 51/Sector B2
Status: active

Groundbreakers

Will Billy Big Rig soon be a robot? Will future forklifts, excavators and farm tractors still have operator cabs? On the road to fully automated driving, off-highway vehicles are already a step ahead of passenger cars. So, will this sector be a trailblazer for all-new working worlds?

By Carsten Paulun

October 2, 2019 is a typical autumnal day in Södertälje, Sweden: eight degrees centigrade (46 °F), an overcast sky, smaller rain showers and a slight but cold westerly wind that later shifts northward – chilly weather. Even so, this day is unusual: Swedish commercial vehicle manufacturer Scania is demonstrating a truck of the future on its proving grounds. The truck is a fully autonomous vehicle. So, what's new about that one might ask. The novelty is that the truck not only has no driver but also no cab. Instead, there are sensors, computers and actuators doing the driver's job. Strictly for monitoring and emergency interventions, a relaxed worker sits in a remote air conditioned office which, theoretically, could be anywhere in the world.

Scania's Swedish competitor Volvo is investing in an autonomous future as well. At its Eskilstuna plant, the company has established a dedicated proving ground including 5G wireless technology for electric and autonomous construction vehicles. Construction sites, gravel quarries and open-pit mining are examples of use cases for such vehicles: off-highway areas with low speed limits, routes that never change and hardly any other type of traffic. They provide an ideal learning environment for autonomous driving and are much better suited for this purpose than the hustle and bustle of big cities with road users whose actions are not necessarily predictable.

Autonomous workers

The working world is a pioneer in autonomous driving anyway. Smaller self-driving transport vehicles have been hauling body panels, engines and other components through factory halls in modern automotive assembly plants and other industrial

From a road tractor, parcel delivery or shuttle service through to a combined drone and minibus taxi: The Schaeffler Mover is suitable for a wide variety of use cases. The platform consisting of the complete drive system, batteries, control electronics and all sensors for autonomous driving always remains the same

operations for quite a while. Initially navigated by signal cables invisibly embedded in the floor, they now head for the respective material depot or next production stage with complete autonomy. Using sensor systems with 3D cameras, lidar, ultrasonic and laser sensors, plus radar eyes, they detect workers that may be crossing the aisles. Self-driving forklift trucks and fully automated robots that pick & place parts in high-bay warehouses and communicate with ERP systems: In factory logistics, the future has already begun. All the vehicles exchange data with and learn from each other. Due to the limited space and the much lower speed level compared with normal road traffic, the factory floor offers an ideal learning field for autonomous vehicles.

Schaeffler's autonomy movement

Automotive and industrial supplier Schaeffler is developing such a self-driving system, too. Thanks to its four wheels, each of which can turn at a 90-degree angle, the Schaeffler Mover can perfectly maneuver in the smallest warehouse aisles and even travel at a 90-degree angle. Unlike the automated industrial trucks, the Mover, after completion of its development, is intended to also operate fully autonomously in urban traffic at speeds of up to 60 km/h (37 mph). A driver will no longer be needed then. Thanks to a modular concept with swab bodies the Mover is suitable for hauling goods as well as passengers. As a driverless road tractor with appropriate up-scaled performance specifications it might even autonomously pull trailers across the country.

Technology eases the driver's burden

Unsurprisingly, such driverless tractor-trailer combinations are at the top of the wish lists of freight hauling companies since manpower costs account for nearly half of the freight costs – provided that personnel can be found in the first place. However, full automation of cargo transportation on public roads is a complex proposition. Until it becomes a reality, partial automation might provide some relief for budgets and the labor market. Platooning is the keyword in this context. It refers to interlinking the assistance systems of several trucks and, provided that laws are amended to permit such solutions, forming a convoy of vehicles closely following each other. Experts are

Autonomous deliveries on the factory floor: Audi began to experiment with emergency shipments of urgently required components using drones in 2017 (top). Industrial trucks from forklift and warehouse technology specialist Linde Material Handling are already traveling through many manufacturing and warehouse halls today (bottom)

The pods from UK startup Starship autonomously deliver food, parcels or tools – initially on company and campus premises

currently considering convoys of two or three trucks to be a realistic option in regions with high traffic density and as many as eight vehicles in countries with vast expanses of land like Canada or Australia. Only the driver of the lead truck has to pay attention to the traffic situation while the crews of the following trucks are in standby mode and can thus use their time for other things. As a result, the job profiles of professional drivers can be expected to change as well: instead of mainly performing a chauffeur's work, they might turn into logisticians who fill out paperwork, schedule vehicles or plan shipping routes.

When the robot rings twice

Courier services are pinning great hopes on autonomous vehicles, too, not only in warehouse logistics but also in the context of delivering goods to consumers. Autonomously traveling electric vehicles serving as self-service delivery and pickup terminals using formats like the Schaeffler Mover are just as much part of the

Autonomous driving, but with what kind of fuel?

The traction batteries of a truck must weigh 7.5 metric tons (8.3 short tons) to achieve a range of 1,000 km (620 mi). For comparison: a tank of diesel provides a range of up 2,500 km (1,550 mi). Consequently, battery-electric drive is not the ideal solution for long distances. The fuel cell is far better suited for this purpose. Read more on this technology starting on page 62.

(desired) portfolio as suitcase-sized micro vehicles or drones, driverless pizza bakeries or ice cream trucks. A lot of things are possible, some of them still in development pipelines and others already on the road in pilot projects. Nevertheless, in this area, the complexity of everyday traffic situations, especially in city centers, still exceeds the capabilities of robo vehicles as well, not to mention legal obstacles. Also conceivable are cobot solutions, in other words a delivery person and a robotic vehicle working together. For instance, the delivery person and an autonomous vehicle might link up close to the area where the deliveries are to be made after the van has been loaded at the parcel center. Another idea is for minivans to follow the delivery man or woman in pedestrian zones at walking speed. These are exciting prospects and it remains to be seen what technology will meet us at our doorstep when the postman rings.

Billed as "smart farming," the agricultural sector has been seeing major technological upgrades as well. In fact, the oldest economic sector on Earth is a technology trailblazer. Some 25 percent of all service robots worldwide are used in farming, according to a report by the International Federation of Robotics. As early as in 2015, one third of the value added in the agricultural machinery sector worldwide was generated with software, electronics and sensor systems, accounting for a three times higher share than in the automotive industry. Autonomously operated harvesters are already a reality in farming today: The machine independently processes information and makes at least partially autonomous decisions while the farmer's role is large a monitoring one. On large fields, the interaction of autonomous harvesters can already be admired: Driverless combines hand over the harvested crop to trailers they have called to the site themselves and which are then pulled by driverless tractors. A driver only sits in a truck at the edge of the field. Like the parcel delivery sector, farming relies on small robotic vehicles, whether for sowing or weed killing. The light-weights have the advantage of causing clearly lower soil compaction than conventional heavy-duty machines.

Autonomous through drive-by-wire

So-called drive-by-wire technology is essential for all autonomous vehicles of levels 2 (partially automated for instance by lane-keeping and speed control assistants) to 5 (full driverless automation). It replaces mechanical actuators in steering, throttle and braking systems by electrical impulses that are executed by servo-motors. The Space Drive system of Schaeffler's joint venture Schaeffler-Paravan sets the benchmark. Space Drive has been used for years in vehicles for people with disabilities and thus has covered more than a billion kilometers in real-world road traffic. The technology, which is completely fail-safe due to three mutually monitoring control chips, is already installed in passenger cars, vans and farming technology. Even in motorsport, Space Drive is proving its viability in an Audi R8 race car modified by Paravan. Moreover, Space Drive is adaptable to a variety of use cases in automotive, construction machinery, municipal and special-purpose vehicle engineering. In interaction with onboard radar, lidar or ultrasonic sensor systems and a matching control unit, Space Drive is able to accelerate, brake and steer vehicles through traffic in fully autonomous mode. Schaeffler provides Space Drive with a "brain" that can be adapted with equal flexibility: the XTRONIC Control Unit from Schaeffler's subsidiary XTRONIC GmbH. The control unit's USP is that it combines safety, monitoring, control and comfort functions in a single system, which makes it suitable for versatile uses across different platforms.

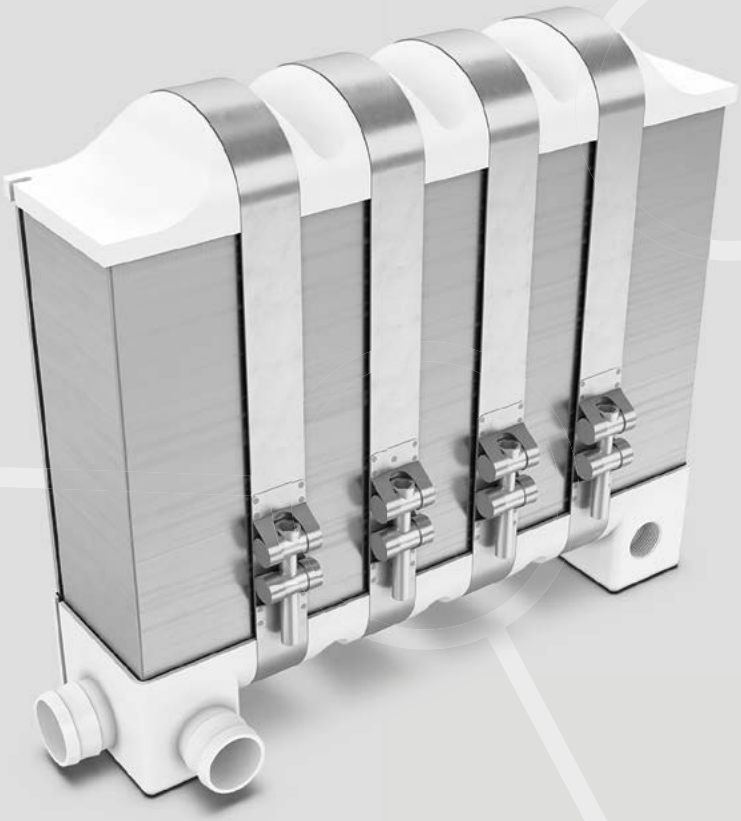
New technologies create freedom

Even at this juncture, autonomous equipment has become firmly established in the routine processes of many industrial sectors. It enhances safety and productivity – and provide us with opportunities to do the things that humans are better at than machines.

The author

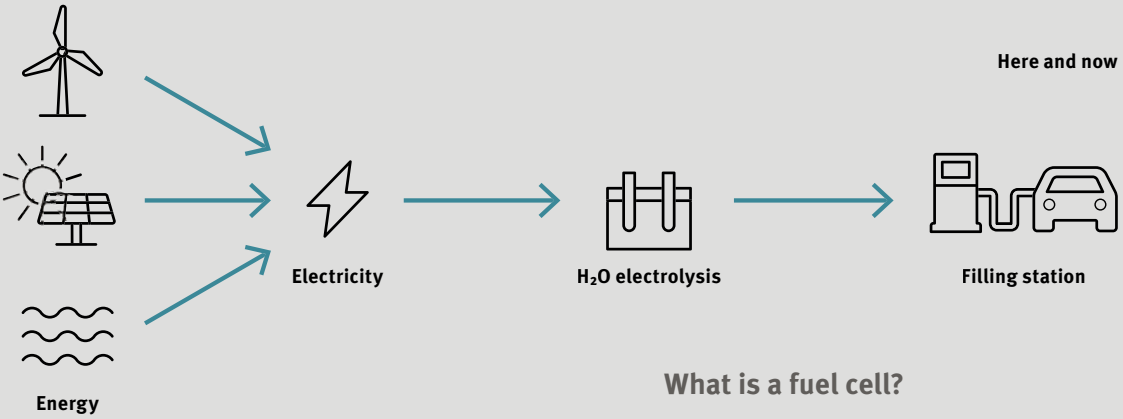
Journalist and techie **Carsten Paulun** started experimenting with remote-controlled ships and cars in his childhood days. At the moment, he's having fun with his drone that's able to autonomously avoid collisions with obstacles.

The fuel cell: an onboard power-plant



Electric powertrains don’t have to involve range issues: The fuel cell is a case in point. How does this technology work and why has it recently become a hot topic? “tomorrow” answers the key questions.

By Carsten Paulun



What are the advantages of fuel cells?

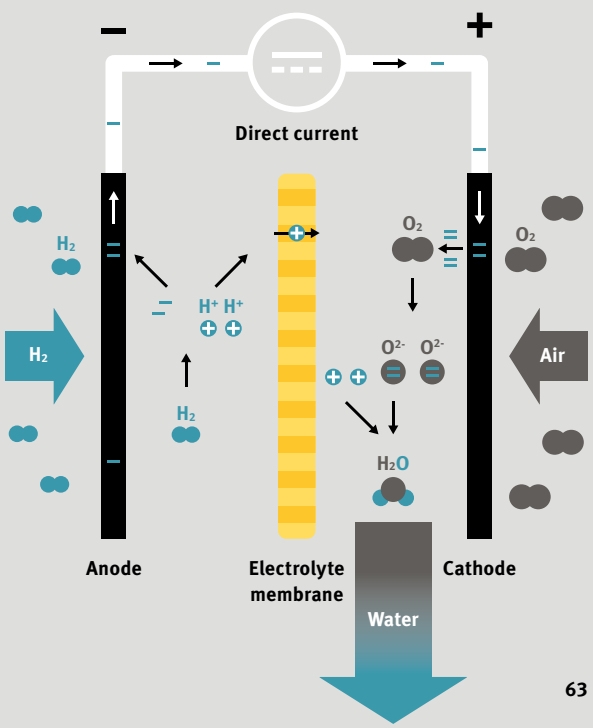
They mainly result from the type of fuel they use: hydrogen. It allows us to store electricity produced from renewable sources by means of electrolysis without harmful emissions and use it as needed. This is particularly important in terms of emissions across the energy chain: from production to fuel tank to wheel. Experts refer to this as well-to-tank and tank-to-wheel or well-to-wheel when looking at the entire chain. Whereas the major losses and emissions of ICE powertrains occur in the vehicle itself, electric powertrains operate with zero emissions, irrespective of whether the traction power is supplied by a battery or a fuel cell. The lion's share of an electric vehicle's losses and emissions is incurred during power generation and storage. However, both of these aspects are negligible if the power is produced from renewable energy sources.

What is a fuel cell?

A fuel cell is a device that converts the chemical reaction energy of a supplied fuel and an oxidation agent into electrical energy. Consequently, unlike most fuels that produce energy as the result of a combustion process, hydrogen – the ideal fuel for use in fuel cells – is not "burned" in the cell. Its energy density of 33.3 kWh/kg (15.1 kWh/lb) is nearly three times higher than that of diesel (11.9 kWh/kg; 5.4 kWh/lb). Plus, in a hydrogen-oxygen bond known as water, it is available in practically unlimited supply. After all, 70 percent of the Earth's surface is covered by water. Moreover, pure hydrogen contains no bound carbon, so the emissions of fuel cells contain no CO_2. Fuel cells can operate with all hydrogen-containing gases such as methanol, coal gas and natural gas. However, unlike hydrogen, these gases always emit CO_2 as part of the transformation process into electricity and water. The oxygen from the ambient air serves as the oxidation agent.

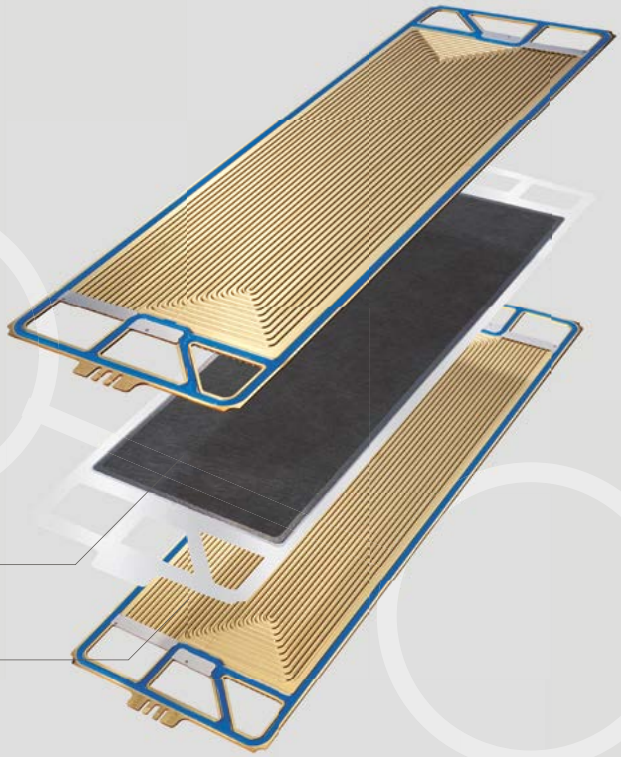
How does it work?

A fuel cell transforms the energy bound in a fuel directly into electrical energy. The composition of a low-temperature PEM (proton-exchange membrane) fuel cell – currently the preferred technology – is similar to that of a battery: an electrolyte, in this case a membrane instead of a liquid, separates two plate-shaped electrodes (anode and cathode) – referred to as bipolar plates in the context of fuel cell technology – from each other. This membrane is able to conduct protons but is otherwise impermeable. It is coated with catalytic materials that promote the fission of hydrogen into electrons and protons. The electrons flow as usable electric current to the cathode via a conductor. The protons also flow through the membrane to the cathode where they meet with oxygen ions that have formed as a result of the absorption of the electrons that have migrated to the cathode. Both react into water vapor and water.



What does it look like?

A single cell may be smaller than a matchbox. Modern single cells consist of three flat discs, two of a thin metal and one of a coated polymer film. As the voltage of a single cell is only between 0.5 and 1 volt, several identical cells are combined into a stack. A 100-kW fuel cell system with pumps, lines, heating system and control electronics for a vehicle powertrain fills the engine compartment of a mid-sized car.



Why has it been a niche product so far?

As a combined heat and power producer in buildings it's (still) too costly. In vehicle applications, the fact that no country has an extensive network of filling stations is another inhibiting factor. It's the old chicken-and-egg problem: for energy corporations, an expansion of the network is not profitable because there are not enough fuel cell vehicles while the automotive industry argues that there's a lack of filling stations.

Why is it becoming attractive now?

In the past, there was no need to use them. "After all, we had wood, coal and petroleum. These fuels were 'lying around' and just had to be ignited," explains Michael Fröba, a professor of chemistry at University of Hamburg. However, in view of the pursuit of carbon-neutral, clean mobility to combat climate change hydrogen-operated fuel cells are an intelligent key technology.

Who invented it?

In 1838, the Swiss-German chemist and physicist Christian Friedrich Schönbein immersed two platinum wires in hydrochloric acid together with hydrogen and oxygen and detected electrical voltage between the two wires – the world's first fuel cell. The British physical scientist Sir William Robert Grove adopted the idea in 1839 and combined several of these cells into a "gas battery" – the world's first usable fuel cell stack.

Why is a battery still needed as well?

Because fuel cells are unable to recover energy, for instance from braking force, but assistance for powerful acceleration makes sense and because energy must also be available for starting the fuel cell. Such batteries, however, can be much smaller than the traction batteries of battery-electric vehicles (about 10 percent of their size).

How efficient is a fuel cell?

A fuel cell generates electricity and heat. Both electric and thermal efficiency may amount to as much as 65%, depending on the design, without considering losses during production, transportation and storage of the fuel. While the electric power is used for propulsion, the heat can be used for heating the car.

What does the capacity depend on?

Decisive for the capacity and durability of fuel cells are the catalytically coated membrane and materials, as well as the coatings of the bipolar plates. The membrane coatings typically consist of carbon and platinum or a platinum-containing mix as a catalyst. To increase capacity, durability, responsiveness and electric efficiency, manufacturers like automotive and industrial supplier Schaeffler are working on various coatings and electrolytes.

How is hydrogen produced?

By means of the chemical process of electrolysis: A positive and a negative pole are immersed in water which causes the water to split into the H_2 and O_2 molecules, i. e. hydrogen and oxygen. Specialty coatings applied to the positive pole (cathode) and the negative pole (anode) and the addition of acid to the water accelerate the reaction and increase the yield. The energy invested in electrolysis "is not wasted but partially transferred to the individual molecules where it remains until the reverse reaction occurs," explains Professor Michael Fröba, PhD.

Are there any maintenance procedures?

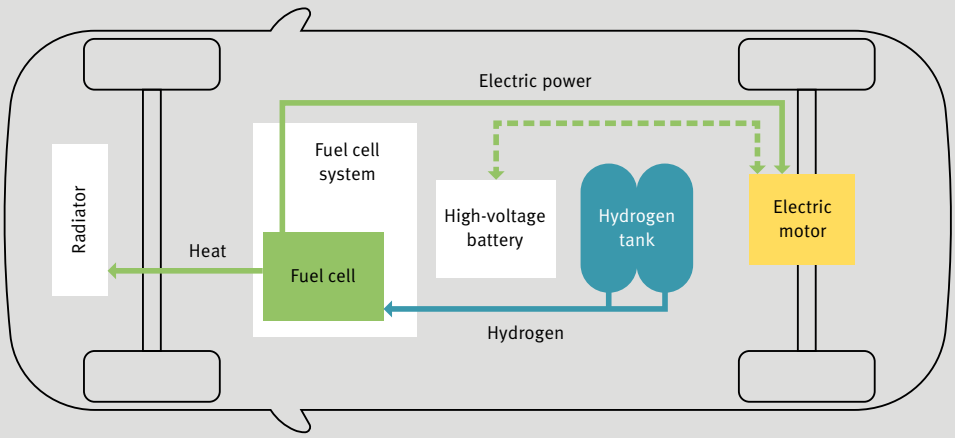
Fuel cells are actually deemed to be maintenance-free. Manufacturers typically require an annual inspection, not least due to the other systems such as the vehicle's brakes and the exhaust system for the fuel cell heater. Their lifecycles are between 5,000 and 40,000 hours, depending on the technology. For a passenger car fuel cell, that's enough for about 300,000 kilometers (186,000 miles).

What are the challenges and risks involved?

Hydrogen in gaseous form can be stored in tanks. However, in order to store a similar amount of energy as a gasoline fuel tank the tank would have to be as large as a warehouse hall. Alternatively, hydrogen can be liquefied at minus 253 degrees centigrade (–423.4 °F) in a very energy-intensive process. The solution is to compress the gas. Today's hydrogen tanks are filled with a pressure of 700 bar (10,150 psi) – the inflation pressure of a normal tire is about 2 bar (29 psi). These hydrogen tanks have multi-layered walls made of diverse materials and are deemed to be crash-proof. Compared to gasoline and diesel fuel, hydrogen even has a safety advantage: it's so volatile that an explosion is near-impossible. In tests run by the University of Miami, a car with a gasoline engine completely burned out whereas hydrogen burned in a huge flash within fractions of a second and then the fire went out.

What components are needed to integrate fuel cells in vehicle powertrains?

The fuel cell itself is a rather compact component. In addition, the system includes air compressors and humidifiers, pumps, voltage controllers, the cooling and heating system, control electronics, a buffer battery and the hydrogen tank, which is the largest component, plus of course the electric traction motor.



Three questions for …

… Dr. Stefan Gossens, Manager Innovation Program Energy Storage and Conversion at Schaeffler.

Why is the fuel cell of interest to Schaeffler?
We regard the fuel cell as a viable complement in the field of new powertrain systems and see our expertise in the areas of materials, metal forming, coating and later of course also in mass production. Obviously, the initial focus is on fuel stacks but in a further step, parts of the fuel cell periphery may be relevant, too.

Where does Schaeffler see potential customers?
There's a wide variety of use cases in mobility, as well as beyond commercial vehicles and passenger cars, in which the emission-free production of electric power is being pursued, such as in the areas of rail, industrial trucks and stationary applications like heat and power cogeneration systems.

In your view, how relevant is the price of a viable fuel cell system to achieving the technology's large-scale breakthrough? And when will this happen?
Today, the high price of the technology is no doubt still an obstacle to its wide-spread use. The aforementioned industrialization as well as further technological developments will significantly contribute to the necessary price reductions from a mid- to long-term perspective. We're going to see this happening during the 2020s, in similar ways as we previously did with photovoltaics and lithium-ion batteries.

» In future mobility contexts, battery-electric and fuel cell vehicles will be able to ideally complement each other. But the fuel cell will also prove its potential in use cases beyond trucks and passenger cars

Dr. Stefan Gossens

How does hydrogen get to the filling station and into the fuel tank?

Special pressurized fuel trucks haul hydrogen to the filling station where it's refilled into other pressurized tanks connected to the respective pumps. Filling hydrogen into a car's fuel tank does not differ a lot from diesel or gasoline, except that there must be a pressure-resistant connection between the pump nozzle and the vehicle. This is ensured by a standardized system which is identical at all filling stations. Pipelines or liquid organic hydrogen carriers are alternatives to pressurized fuel trucks. In that case, hydrogen can be transported like any other fuel. At the filling station, the hydrogen is subsequently extracted from the carrier liquid again.

Where and when will it be used in the future?

Manufacturers like Nikola (USA) and Hyundai (South Korea) are planning to deliver the first truck tractors with fuel cell powertrains in 2020. German railroad operator Deutsche Bahn is currently testing trains with this technology in passenger transportation. They're intended to replace conventional diesel locomotives on tracks without overhead wiring. In the aviation sector, manufacturers like Airbus and Boeing as well as research institutions such as the German Aerospace Center are intensively working on fuel cell aircraft. American manufacturer Zerovia is planning to equip at least smaller business aircraft with up to 20 passenger seats and ranges of up to 800 kilometers (500 miles) with fuel cell propulsion systems starting in 2022. Already close to production is the push-boat Elektra involving a consortium of partners including fuel cell manufacturer Ballard Power Systems. Fielding of the boat is scheduled to start in 2020 for hauling goods between Hamburg and Berlin on the rivers Elbe and Havel.

Where can fuel cells be used as energy sources for propulsion?

In all areas where battery-powered electric drive systems are either not economical or not feasible due to their size or weight and where long ranges with short refueling times are crucial: passenger cars, trucks, aircraft, ships and rail vehicles. "With fuel cells, they can also be operated with zero CO_2 and other emissions," says Professor Dr.-Ing. Tim Hosenfeldt, Senior Vice President Innovation and Central Technology at Schaeffler. The high "system efficiency of the fuel cell which clearly exceeds that of internal combustion engines primarily speaks for its use in means of transportation. In addition, local zero emissions of nitrogen oxide, CO_2 and fine-dust particulate speak for this form of propulsion," according to the German Federal Ministry of Transport and Digital Infrastructure.

The author

As head of the "automobile" editorial team of Germany's national daily newspaper BILD-Zeitung, our author **Carsten Paulun** drove fuel cell prototypes as far back as in the mid-1990s and has been fascinated by the silent, zero-emissions technology ever since. At the moment, he's thinking about replacing his oil heater at home by a fuel cell system.

The enablers

Schaeffler's success story is closely linked to its own production landscapes. Without the equipment and manufacturing lines from its in-house mechanical engineering department, Schaeffler's worldwide plants would stop operating. The production process know-how that was previously used only internally is now available to external companies as well.

By Oliver Jesgulke

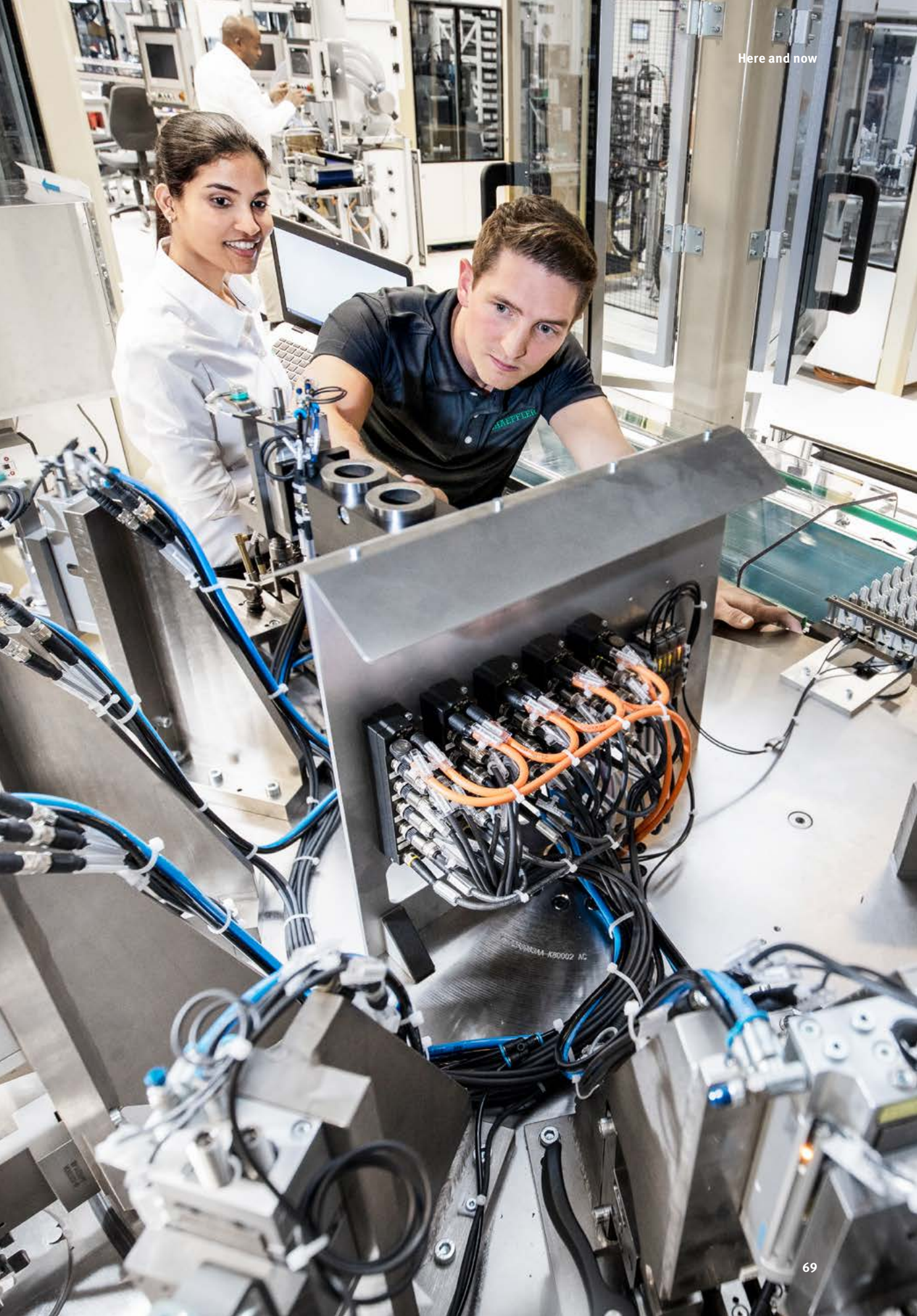
The 1,800 mechanical engineers at Schaeffler tackle any technical challenge posed by a product or a completely new production process. The portfolio of these resourceful specialists encompasses metal-cutting machines, assembly automation, inspection technology and IT solutions in the production environment. It's focused on specialized solutions for manufacturing automotive and industrial products that are not available on the market. More recent highlights include the development of prototypes, complex assembly or inspection lines for hybrid modules, the thermal management module and the new E-axle transmission systems produced in Herzogenaurach for Audi and Porsche models.

"We define ourselves as 'partners for production excellence.' The relationship with our production sites in a spirit of partnership has a decades-long history of guaranteeing that our plants operate like Swiss clockwork and our products meet the highest quality standards," says Bernd Wollenick, who is responsible for the worldwide special-purpose machinery network with 16 locations. About 50 percent of the group-wide demand for production equipment is met by the in-house special-purpose machinery engineering unit.

The business unit has a total assembly area of some 30,000 square meters (7.4 acres) equating to the size of four soccer fields. This is where the equipment and machines Schaeffler uses to manufacture far more than 10,000 different products are created.

On board from day 1

Wollenick's teams contribute their expertise at a very early stage: whether the project involves small-volume production or a high-output line, manual work or fully automated processes. "A product to be manufactured in our environment may change 1,000 times in its creation stage and many of these modifications are machine-relevant. That's why we sit at the table as early as in the product design stage of our customers," Wollenick explains. "Production costs are incurred in product design, and with our agile methods and simultaneous engineering, we ensure manufacturing and economic feasibility." The electromechanical roll stabilizer that enhances driving safety and went into production in 2015 is a case in point. Its product weight of 14 kilograms (31 lb) and length of up to 1.4 meters (4.6 feet) alone make the handling processes more difficult within the planned assembly and inspection lines. For this and other reasons, it was



One

technology database with worldwide access that stores complete information about processes and results is available to the special-purpose machinery unit. In concert with extensive standardization and identical user interfaces of the machines, cycle times can thus be reduced by as much as 30 percent.

3,000

turning and milling centers and more than 3,500 grinding machines are used at Schaeffler's plants worldwide.

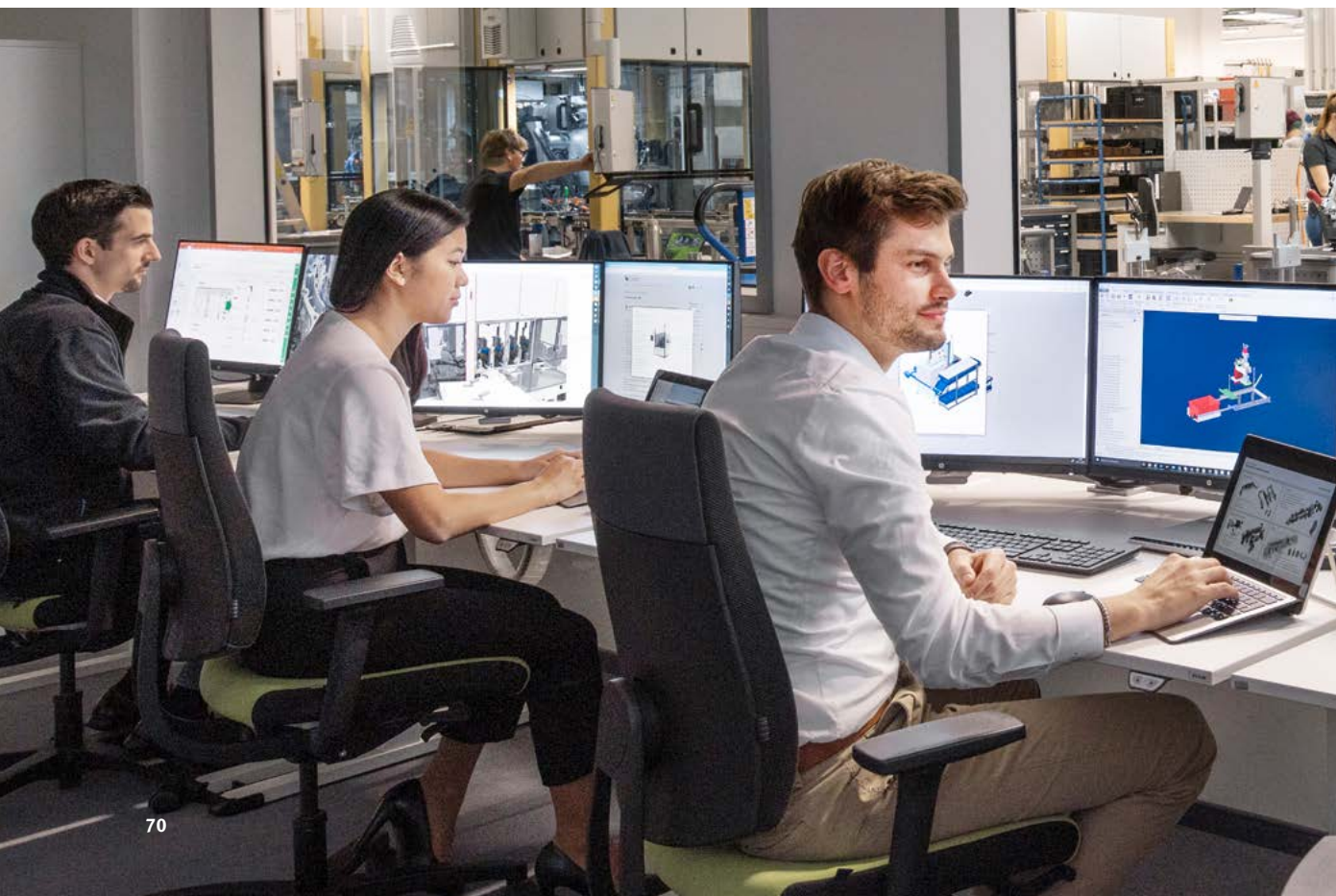
essential to plan the required production equipment to ensure that the individual components could subsequently be assembled.

Uniqueness protects against copycats

Brothers Dr. Georg und Dr. Wilhelm Schaeffler deliberately relied on machines of their own on the factory floor early on. In 1960, the first "tooling and equipment engineering department" began its work in Herzogenaurach.

The decision was supported by the conviction that technically sophisticated products could be produced in-house in the most economical manner by developing and exclusively using the company's own machines instead of purchasing them from external suppliers. In this way, Schaeffler secures important manufacturing and assembly know-how and shortens time-to-market for complex products. This in turn enhances the company's independence and leads to competitive advantages. Only few machines actually end up in third-party hands as part of the systems business, such as the assembly equipment for Schaeffler's propshafts that have been a top seller for 50 years: a principle that has proven to be viable to this day.

"When you look at the many hidden champions in this country you'll see that most of them have their own mechanical engineering



> *» We guarantee that our plants operate like Swiss clockwork*
>
> Bernd Wollenick,
> Head of Special-Purpose Machinery Engineering
> at Schaeffler

departments for the factory floor," says Wollenick. "Besides creating special quality products, this makes life more difficult for the world's copycats." When he took the helm in 2007, such departments existed at several major Schaeffler locations, but all of them were working in isolation. Wollenick reorganized them and merged the individual departments into a global unit with standardized processes and work principles.

He went on to drive the internationalization of the special-purpose machinery unit, primarily in China and Slovakia. Today, the largest facilities of the global network are located there. The move to Erlangen in 2017 with a concentration of diverse skill sets in a new headquarters with space for 650 employees marked another milestone.

Campus life promotes collaboration

As soon as you enter the building you can tell that this business unit lives collaboration and innovation on all levels. Colleagues – whether engineers or skilled workers – from diverse functions and across department boundaries work together in shared spaces. Everything has been designed according to the New Work concept – from shielded multi-spaces to writable walls. None of the employees has a permanently assigned workspace. "We look for a place that fits the requirement and constellation of the team and project work that's important to us," says Wollenick. This was a novelty at Schaeffler and the concept has produced a noticeable increase in efficiency and innovation.

The 1,800 specialists in the special-purpose machinery unit deliver everything from a one-stop shop: from the initial idea to the development, design and production of machines

The range of machines developed by Schaeffler spans from robots that have no direct contact with humans and work at high speeds to highly sensitive cobots requiring no boundaries

"From here we control a global network with 16 locations and are able to realize large-scale international projects across locations: from the initial machine or line concept to stable zero-defects production," Wollenick explains.

Measured by its numbers, the business unit is even one of the world's major special-purpose machinery producers today. Nearly 4,500 projects and orders were implemented in 2018 with annual sales amounting to 363 million euros – in very challenging times. "Lean" is in. Lead times and innovation cycles are getting shorter. Due to the major changes in the automotive sector and the product offensives with hybrid electric and battery electric vehicles, the business unit has to establish machines and lines for volume production at an increasingly fast pace. However, today's environment calls for more than just setting up the systems. 360-degree support is in demand: in addition to planning, consulting, project design and development, the service portfolio of the unit encompasses quality assurance, machine maintenance and customer training for long-term operation.

Special-purpose engineering 4.0

Like Schaeffler's product portfolio itself, the production processes are subject to continuous change. The progress of digitalization has a major share in this. Consequently, the special-purpose machine engineers also focus on equipping and connecting existing machines and new generations with smart software solutions, sensors and

Partner for Production Excellence – Schaeffler's special-purpose machinery engineering on YouTube

interfaces. Tracing systems for end-to-end quality assurance of products have been developed as well. Traceability detects defects in time and thus helps avoid costly recalls. Vision systems for quality assurance of manufacturing processes by means of artificial intelligence are moving into focus, too. These systems use high-resolution industrial cameras that recognize the geometry, color or position characteristics of products as well as counterfeits.

In addition, the business unit designs, develops and installs technologies in the area of human-robot collaboration (MRC). The product portfolio extends from automated high-speed pick & place applications to highly complex assembly processes using collaborative robots. These cobots are the fastest growing segment in the robotics market. In addition to the classic industrial robot that, permanently installed in a cage and shielded from its human colleagues, keeps performing the same staccato-like movements over and over, this is a smart way to achieve automation in collaboration with humans.

Machine parts from a 3D printer

Schaeffler has been using 3D printing technology for many years. Engineering designers have access to a wealth of tools, from the concept design to the printed component. The technology increasingly enables the production of spare parts and complex plastic or metal machine components. The special-purpose machinery unit also uses these benefits for so-called additive manufacturing. Today, one in two machines already contains at least two components from a 3D printer: a trend that will continue to grow.

New markets, new horizons

Along with the tasks, professional fields and job profiles change. Bernd Wollenick's team of mechatronics specialists, mechanical and electrical engineers and technicians, technical writers and sales experts has been joined by 100 software developers. This is another growing trend although there's yet another trend that's far more important: The special-purpose machinery unit is increasingly opening itself up to other sectors. "By opening ourselves to other markets we want to actively benchmark ourselves and aggressively place competitive technologies in the marketplace," Wollenick explains. The business unit is currently involved in numerous discussions with potential new customers.

They include international manufacturers in diverse sectors who are interested in metal-cutting machines, assembly and inspection lines or handling and feeding technologies from Schaeffler. "All sectors are conceivable. This will not only broaden our horizons but in turn also enhance our traditional business." But even the move from a specialized to a mass market is no longer taboo for Schaeffler. The demand for lean, capital expenditure optimized machines at a lower price is high, especially in emerging markets."

"However, this is a real balancing act," Wollenick cautions. "Our special-purpose machinery engineering is the operational backbone of the Schaeffler plants and quality 'Made by Schaeffler' is our spinal cord. This will always be our top priority – in keeping with the proven tradition established by our founders."

1 to 2

new plants are opened by Schaeffler every year, which has resulted in an addition of one million square meters (247 acres) to Schaeffler's worldwide production network in the past 15 years.

18 months

is the average time that elapses between the **decision and launch** of a new Schaeffler plant. Not only the machines but also the entire material flow and space utilization concepts are based on identical worldwide standards.

Outlook

Technology for tomorrow

Moon

Distance 384,400 km (238,850 mi)

SpaceX Starship

Start 2023
Crew 100
Destination Moon, subsequently Mars
Payload 150 metric tons (165 short tons), three times as much as the Saturn V launch vehicle for the Apollo missions
Liftoff thrust 74,000 kN (Saturn V: 34,000 kN)

SpaceX CEO Elon Musk is planning for people to start orbiting the Moon in the Starship starting in 2023 and subsequently colonizing Mars. As with the previous Falcon rockets all components are supposed to be reusable. Initial prototypes are currently in the making.

Ariane 64

Start 2021
Crew 4
Destination GEO, Moon
Payload 11.5 metric tons (12.7 short tons)
Liftoff thrust 14,000 kN

The European launch vehicle is planned to start carrying satellites into outer space in 2021. For 2022, the liftoff of the space capsule Orion is planned, which is supposed to take four American astronauts into a lunar orbit and in 2024 even to the Moon.

GEO
Geostationary Earth Orbit
35,790 km (22,180 mi)

MEO
Medium Earth Orbit
2,000–35,790 km (1,250–22,180 mi)

LEO
Low Earth Orbit
200–2,000 km (125–1,250 mi)

Balloon

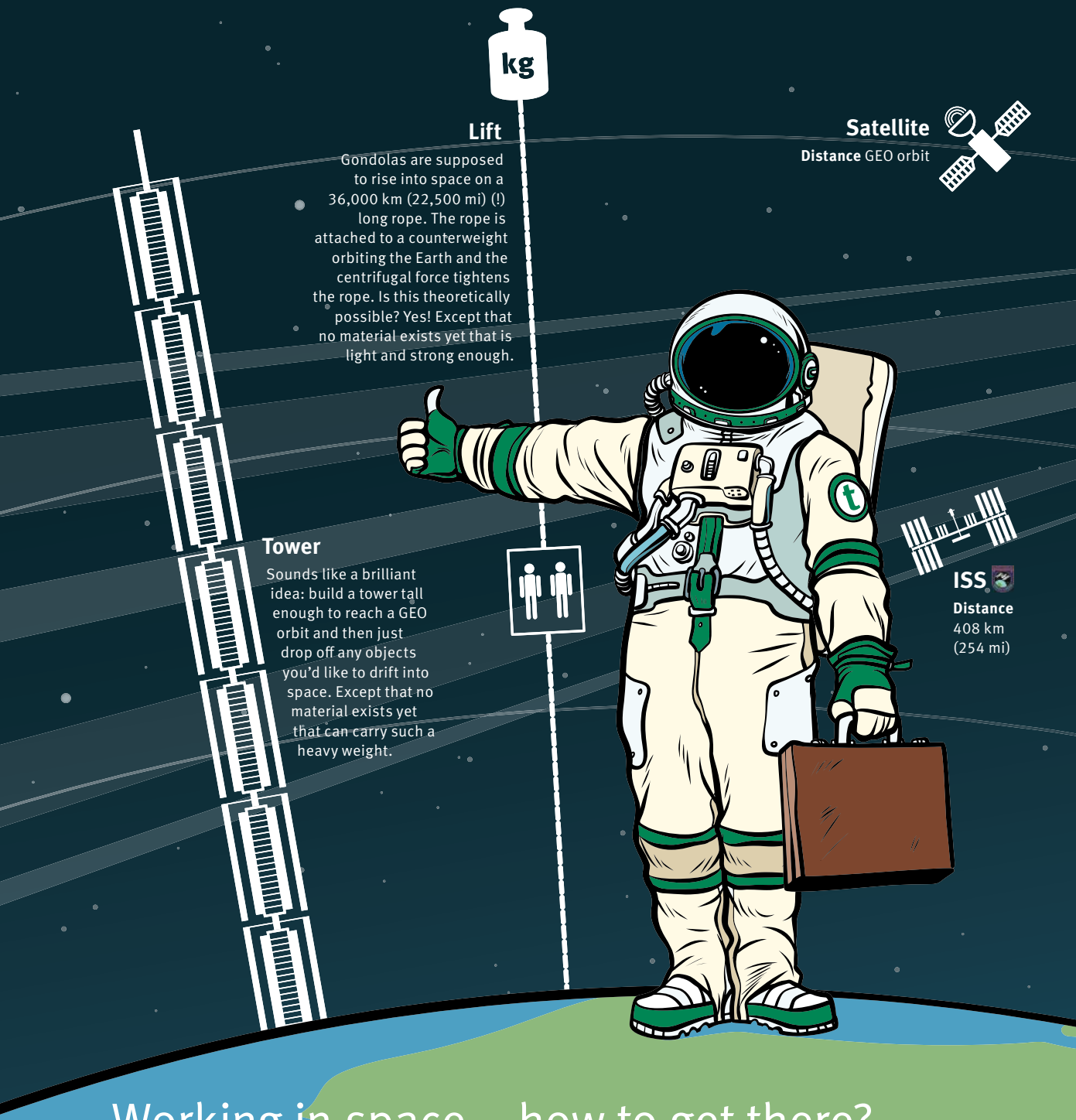
As far back as in 1960, Joseph Kittinger jumped from a balloon at an altitude of 31 km (19.3 mi), in 2012, Felix Baumgartner from 39 km (24.2 mi) and in 2014, Alan Eustace from 41 km (25.5 mi). About 57 km (35.4 mi) mathematically mark the end of the line – the thin air at this altitude will no longer carry any balloon.

» Beam me up, Scotty
Mr. Spock

VSS Unity

Start 2021
Crew 8
Destination outer space (110 km; 68 mi)
Payload N/A
Liftoff thrust 310 kN (carrier aircraft: White Knight Two: 120 kN)

The spacecraft built by Virgin Galactic is released by a carrier aircraft at an altitude of 15 km (9.3 mi) and at a speed of 4,200 km/h (2,600 mph) is propelled vertically to an altitude of 110 km (68 mi). At the boundary of outer space, the engine is shut off, the spacecraft tilts toward the Earth, starts to sink and at an altitude of 16 km (10 mi) starts its landing approach.



Working in space – how to get there?

Because we can do it, because we must do it and because it – literally – offers boundless expanses and opportunities: Outer space as a place of work is increasingly in vogue. According to UN estimates, about eleven billion people will be living on our planet by 2100 – making for cramped conditions down here. Outer space offers alternatives: We'll be designing space stations – much larger than ISS and co. We'll be building factories in which weightlessness will enable us to develop new materials and manufacturing technologies for better products. In space, we'll be breeding useful plants that will feed us. In a nutshell: we'll be working in outer space and perhaps even live there some day. However, the question is how we'll commute between Earth and space?

A machine to be reckoned with

Google and IBM are working on quantum computers that can perform complex computations a lot faster than the world's fastest supercomputers. Now, what's in it for us?

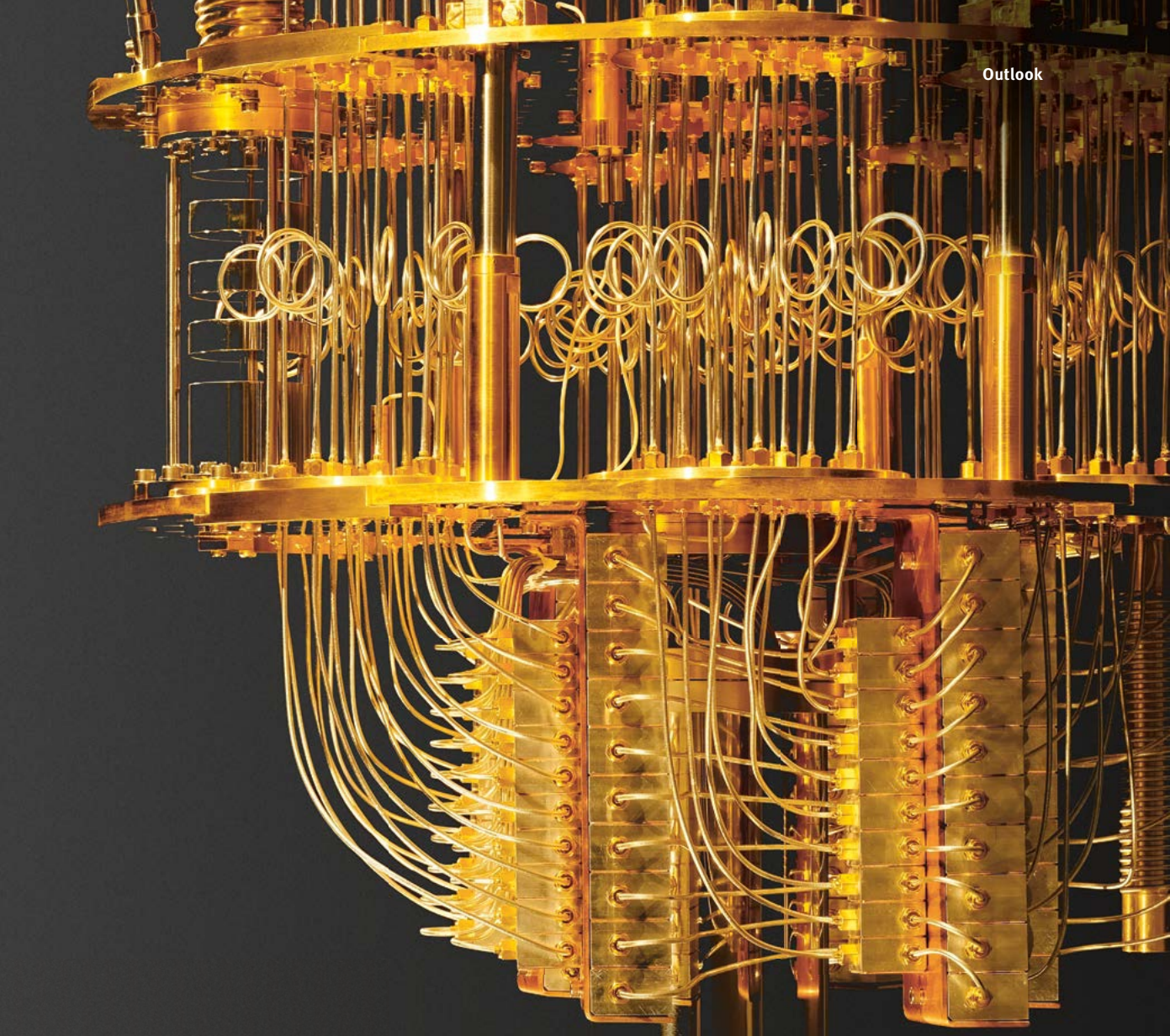
By Denis Dilba

The international community of physicists is still excited about the issue: Has Google's quantum computer "Sycamore" actually achieved so-called quantum supremacy as the scientists from Mountain View wrote in their paper published in the October issue of the science journal "Nature" – or "just a little" as their main competitor, IBM, was quick to argue in a paper of its own?

The search engine giant states that it took Sycamore exactly three minutes and 20 seconds to perform a task known as random circuit sampling, which is about having the quantum computer calculate numerical sequences and subsequently testing if they truly follow a distribution specified by quantum physics. It would take its adversary, "Summit," a supercomputer based on normal bits and bytes, 10,000 years to solve the same computing problem. By the way, Summit, the world's fastest supercomputer since 2018, is from IBM.

Job sharing by quantum and supercomputers

Director of IBM Research Dario Gil wasn't just going to leave this outcome uncommented: If intermediate results of this computation were to be stored on hard discs instead of in the random access memory, it wouldn't take Summit 10,000 years but, in the worst case, just 2.5 days. Consequently, it wasn't appropriate to talk about true quantum supremacy in its strict definition that a conventional supercomputer was totally chanceless against a quantum computer in solving specific problems.



Gil is even critical of the use of vocabulary: The word “supremacy” implied that quantum computers were always better than supercomputers and will completely displace them. That, however, is exactly not the case, says Gil’s German colleague Ingolf Wittmann, who drives quantum computing in Europe: “Instead, quantum computers and conventional supercomputers will be sharing jobs in the future.”

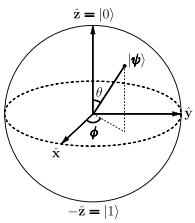
Qubits instead of bits

Quantum computers will only be used where conventional supercomputers reach their limits, the expert explains. For instance, in the field of chemistry: “The composition of the caffeine molecule is not particularly complicated and has 95 electrons. However, if you wanted to calculate its exact binding energy you’d need more classical bits than atoms exist in the universe.” A quantum computer with 160 quantum bits – abbreviated as qubits – would be able to solve this problem, according to Wittmann’s assessment. The massive difference in computing power is that qubits function in a completely different way than normal bits. While the latter can always just assume the two values of “0” or “1,” an intermediate state exists for qubits, which means that the qubit can represent both values at the same time. However, the whole thing only becomes really exciting when several qubits are combined, which physicists refer to as entanglement.

Performance grows exponentially

If two entangled qubits simultaneously contain four states, this means eight states with three

A small quantum glossary



Quantum computers use the states of 0 and 1 – as well as all the others in between

Qubit or quantum bit

The elementary computing unit of a quantum computer, which may be an atom, a photon or neutron that uses effects of quantum mechanics to represent exactly two states, such as 0 and 1, similar to the bits in a conventional computer.

Superposition

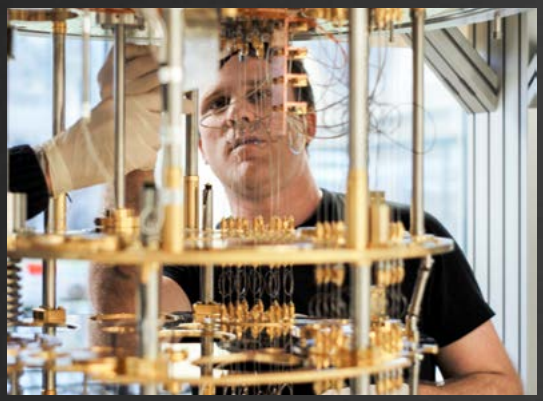
Qubits can be in the two states of 0 and 1 at the same time – which is referred to as superposition. They'll "choose" a state only when being measured. Quantum algorithms can use superposition to massively shorten computations.

Entanglement

Einstein referred to this quantum effect also as "spooky action at a distance." When two qubits are entangled in superposition any changes of one qubit will immediately impact the other one – no matter how far apart they are from each other. Quantum algorithms take advantage of this.

Quantum supremacy

The expression refers to the point in time at which a quantum computer is able to solve a specific complex problem much faster than a conventional supercomputer based on silicon chips.



Quantum computers are complex technical systems. They have practically nothing in common with normal PCs – and even existing supercomputers – also in terms of engineering design

qubits, 16 states with four qubits, and so on. The number of states grows exponentially with the number of entangled qubits. 20 qubits roughly equate to the computing power of a classic notebook, says Wittmann. Systems with 53 qubits such as Sycamore and those offered by IBM as well are ranked in the high-performance computing (HPC) class led by Summit. HPC computers are continuously improving, too, says Wittmann. However, the workhorse Summit already has a 520 square meter (5,600 square feet) footprint and a power rating of 13 megawatts. If its computing power were to be doubled, its footprint and power rating would double, too. To achieve the same performance increase of a quantum computer it would only be necessary to add a single qubit. That, however, is no mean feat: qubits that IBM and Google are talking about are atoms which in complex apparatus have to be cooled down to near-absolute zero, i. e. to 15 millikelvin (–273.135 °C / –459.675 °F).

Resolving a conflict

However, by comparison, this is almost the easier part of the task. The other one, that is the required

> ***If you think you understand quantum mechanics, you don't understand quantum mechanics***
>
> Nobel prize winner Richard Feynman, American physicist (1918–1988)

A new age of information technology: Google CEO Sundar Pichai presents the quantum computer named Sycamore

ability to systematically manipulate these cryogenic atoms while protecting them against external influences, calls for even more engineering tricks. A lot of time will pass before a real universal quantum computer with about one million qubits that more than likely would also be able to unlock all current conventionally used encryption technologies exists. "We're anticipating a period of 20 to 30 years," Wittmann explains.

Even so, he says, it pays for companies to pursue the subject of quantum computers even at this juncture. For one, because the first smaller computations with which quantum computers achieve a real advantage over conventional computers can be expected to be available in the next three years. And for the other "because one should know how to use a quantum computer once it's arrived."

Autonomous driving as a use case

That's why many companies are already evaluating what computing problems would be suitable for a quantum computer. In addition to calculations of chemical compounds in medicine and industry, they include optimizations or portfolio risk analyses – as well as the acceleration of production process flows, which not only saves costs but also improves the quality of the products and thus enhances customer value. A practical case in point: the complex computations for autonomous driving will only be possible with the help of quantum computers, according to Volkswagen's assessment.

Schaeffler is keeping track of the subject of quantum computers with great interest as well. Schaeffler and IBM experts most recently engaged in an exchange on the subject at the end of October. Many of the aforementioned use cases for the mega computer are highly attractive for the automotive and industrial supplier. Therefore, Schaeffler's answer to the question "What's in it for us"? is: quite a bit – at least expectations.

The author

After the news broke of Google's quantum computer breakthrough, science and technology writer **Denis Dilba** was nervous for a moment. Following his research for this article, he's now at ease, knowing that the cryptographic protocols of his Bitcoins will be safe from being unlocked for a while.

Digital vistas

Data glasses were a hot topic a few years ago before fading into obscurity for quite a while. Now a new generation is venturing the move into the B2B environment.

By Oliver Jesgulke

An open furniture catalog on the floor and a camera phone in our hands: that's all it takes for us to see how the new easy chair would blend in with the existing décor of our living room. Digital technologies like augmented reality (AR) enhance the real world by providing additional digital information. However, a deeper immersion in these new digital worlds requires an additional technology. It's called virtual reality (VR) and is often mentioned in one breath with AR. Now data glasses are coming into the picture. They beam users into a completely virtualized world.

Industry experts expect AR and VR to enable innovation leaps and new ways of working together. The automotive sector alone is planning to invest more than 11 billion euros in such technologies by 2021 worldwide, according to a joint survey conducted by Accenture, one of the world's leading technology consulting firms, and the German Association for the Digital Economy (BVDW).

Taking smartphones to new levels

In 1968, computer graphics pioneer Ivan Sutherland presented an initial form of data glasses that projected three-dimensional images directly in front of the user's eyes. The contraptions they required were so large and heavy that they had to be suspended from the ceiling. Today, smartphones are playing a key role in connecting the environment and users with digital knowledge. With GPS, motion sensors and WLAN, the devices are equipped with everything it takes to deliver the desired information. Mobile AR browsers enhance the surroundings the user views through the camera with data from the internet – information about historic events, real estate that's up for sale in the vicinity, the way to the next ice cream parlor or to the street corner where we parked our car. However, when using smartphones for this purpose we still don't have both of our hands free.

A few years ago, Google's augmented reality device billed as "Google Glass" flopped. In the aftermath of this failure, work on refining the technology tended to be done without much fanfare. Subsequently, Microsoft for instance launched its HoloLens product as a form of mixed-reality glasses. They expand reality for their users by animated three-dimensional elements: AR and VR rolled into one in a manner of speaking. The glasses weighing almost 600 grams (21 ounces) can be operated by means of gestures, voice commands or head and eye movements. Hardware and software are directly installed in the headset.

Maintenance made easy

As a result, use cases in the industrial environment have increased within a very short period of time. The technology facilitates distributed teamwork, i. e. team members working at different locations, and even non-experts are able to perform specific jobs without any specialized knowledge. AR applications already provide on-site service technicians with step-by-step explanations of how to replace and repair components. NASA tests of HoloLens have shown possible uses in the maintenance and repair sector as well: during difficult repair jobs in outer space the technology not only enables video conversations with technicians on Earth but can also project additional information as holographic illustrations directly into the astronaut's field of vision.

Microsoft's HoloLens reflects animated three-dimensional elements into the wearer's field of vision

Work with VR glasses offers a wealth of new opportunities

Designing with VR and AR

In the automotive industry, AR and VR are used as well. Virtual reality environments are available to engineers and designers for prototype development. The employees are present there in the form of avatars and jointly work on 3D models of vehicles. Components, interior design elements or exterior colors can be changed in a matter of seconds in this way – enabling modifications that would take hours or even days in the real world.

Not fit for mass production

However, some experts feel that currently available AR data glasses are inadequate especially for use in the B2B environment. Rigo Herold is one of these critics. He is a professor of Digital Systems at Westsächsische Hochschule Zwickau (WHZ), a university of applied sciences, and is one of the leading experts in this field. “It’s simply not possible to produce off-the-shelf data glasses for professional uses. Like an iPhone for all. This lack of scaling has deterred many investors and CEOs,” he says, and caused Google Glass to fail, too. Several manufacturers have since disappeared from this market or reduced their commitment. “When you get your glasses from an

Focused on industrial use cases

Prof. Dr.-Ing. Rigo Herold is a research scientist and teacher in the field of Digital Systems at Westsächsische Hochschule Zwickau. His research is focused on the hardware development of data glasses in the industrial environment and their deployment and integration in company systems. He began to work in this field as far back as in 2006 and obtained his PhD with a dissertation on this subject.

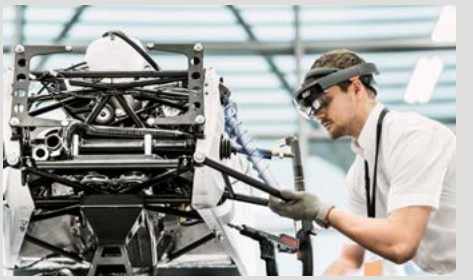
optician they'll obviously be adapted to your personal needs, but this is not possible with the data glass models currently in existence," he adds. Short battery runtimes and quickly aging processors that are permanently installed and cannot simply be exchanged are problematic, too. Herold wanted to come up with a better solution and invented a modular kit system. Processing power and all data are run on external devices while the headset of the smart glasses projects the contents for the user to view. The system can work together with any computer or smartphone. A camera module that transmits individual images or videos via a WLAN connection can optionally be installed.

Customized data glasses

This approach minimizes the utilization of electronics within the headset. As a result, data glasses can be customized and attached to various carriers such as protective helmets and goggles. Herold founded a spin-off for mass production. His glasses are already in use in areas like intralogistics and machine maintenance at VW. For the Dortmund Fire Department, Herold developed a respirator mask that provides members of rescue squads with information such as digital buildings and escape plans or instructions by mission control. Connected to a sensor suit, information about vital signs is additionally displayed in real time. Herold is currently working together with other scientists on a prototype featuring sewn-in hyperextension sensors that log the movements of arms and legs. Another sensor measures the extension of the back and an electrocardiogram (EKG) displays heart rate. Herold can also image the cyber suit being used in high-performance sports, in steel mills or for SWAT (special weapons and tactics) teams in law enforcement.

Next level: the data pupil

Three years ago, electronics corporation Samsung had a smart contact lens patented, which combines a camera, motion sensors and a display. By means of this technology, a user may for instance select an option by means of an eyelid movement: the blink of an eye that will sooner or later cause a considerable sensation in the automotive industry as well.



AR and VR in use at Schaeffler

Schaeffler is already using AR and VR technologies for the commissioning, maintenance and repair of machines and equipment. This includes training apprentices in setting up machines and the utilization of specialist support in machine troubleshooting contexts. The use of these technologies helps cut travel costs and increase machine availability, among other things. In addition, VR enables efficient layout planning in the digital factory.

The author

As much as technology journalist **Oliver Jesgulke** would enjoy having a display in front of his eyes: As far as he's concerned, the usefulness of data glasses hinges upon the quality of internet coverage. And this still leaves a lot to be desired even in the middle of Berlin.

Let's talk about future

Digital technology and automation are changing the future of our working world. For industrial sociologist Martin Krzywdzinski, algorithms and machines neither pose a threat to humanity nor are they the ultimate saviors.

Interview: Oliver Jesgulke

Mr. Krzywdzinski, at the moment, the debate in the media vacillates between paradisiacal ideas à la "The need to work will end!" and horrific scenarios like "Machines will take control of humans!" What are your personal views of the future world of work?

The debate about this is imbued with way too much drama. I personally do not believe that in the future we're all going to be lying in hammocks or that we'll be seeing a major wave of unemployment in industrialized countries. Technological change has always existed, just like the discussions about it. Productivity gains due to machines primarily mean progress. It started with the industrial revolution in the 18th century. Then there was Henry Ford, and now we've been experiencing the digital revolution for a few decades. Naturally, this has the effect of machines being able to handle more and more of the things that humans do. At the same time, employment has continually increased because the economy has kept growing, too. Especially in the industrial environment, the level of automation is high – even so, we've been seeing record employment rates across the value chain in this country in recent years.

A frequently cited study by Oxford University analyzed the probability of automation for a range of different jobs. What's your assessment of such predictions?

You always have to interpret such studies with caution. This particular one was primarily focused on the fraction of routine activities in occupations that were evaluated based on job descriptions. This resulted in the conclusion that the higher the routine fraction of a job, the higher the alleged risk of substitution by automation. Whether or not companies will actually opt for such substitution is a different question. For instance, it depends on how much an automation project would cost. Forecasts like this one do not consider this aspect at all. Obviously, some job profiles are going to disappear. But so far the past has always shown that major technical game changers resulted in all-new job profiles – including new skill requirements. Consequently, there's a shortage of specialists in many sectors today. At the same time, such periods of change obviously raise the question about who will tend to be disadvantaged. The modern logistics centers of online stores are such a negative example: Warehouse workers often perform standardized jobs there that require no skills and are poorly paid. Nobody can bear up to that for a long time.

What technologies are changing the way we'll be working in the future?

There are many examples. Technology is coming into closer touch with humans, for instance in the form of wearables such as data glasses (see also page 80). Enhanced models make this technology viable in areas like remote maintenance and logistics. At the same time, some pilot projects fail simply due to lack of employee acceptance – whether in terms of operability, wearing comfort, display resolution, or battery runtimes. In any event, there's still plenty of potential here and questions of data security have to be resolved. 3D printing is another field. In this case, the optimism of companies varies, depending on the markets they serve. Although large-volume production by 3D printing is not feasible yet, the technology can replace and optimize manual routines in activities like rapid prototyping, so that concepts and ideas can be realized faster.

How can the workforce across all hierarchies keep pace with technological change?

It's not enough for companies to just recruit top talent and to buy skills externally. They also have to tap into internal resources and offer their employees opportunities and room for dealing with data-based technologies and gathering experience. Anyone working with artificial intelligence should be able to judge according to which principles it works. HR departments have to bring together diverse skills for this purpose. The learning architecture should pay attention to an interdisciplinary alignment of skill profiles. For instance, the combination of classic engineering knowledge in the field of automation with modern approaches to software development is becoming increasingly relevant. Moreover, it makes sense to think about alternative development paths that may subsequently lead from maintenance or tooling functions to software development in order to contribute appropriate

About Dr. Martin Krzywdzinski

PD **Dr. Martin Krzywdzinski** is one of seven directors of the Weizenbaum Institute in Berlin and head of the Globalization, Work and Production research group at the Berlin Social Science Center (WZB). He holds a PhD from FU Berlin and obtained his habilitation in sociology there. He is co-director of the "Good Work" doctoral program at the WZB and member of the international automotive research network GERPISA steering committee. He's also a board member of the industrial and labor sociology section of the German Sociological Association.

» Lifelong learning has long ceased to be a buzzword

know-how. In this area, I'm still seeing a lot of room for improvement with the majority of German companies. Plus, young employees in particular will have to be prepared for the fact that "lifelong learning" has long ceased to be merely a buzzword.

How can companies promote acceptance of change among their employees?

If everything in the wake of digitalization just revolves around speed, efficiency and the intensification of work, this automatically results in resistance and the previously praised efficiency gains are lost. Let's face it, digital transformation hinges on acceptance by the entire workforce – not only by young, digitally savvy employees. After having worked as a machine operator at a factory for forty years, it's only natural that I'll initially perceive digitalization as a threat. On the other hand, new tools can broaden one's own horizon and replace tedious routines. It's necessary to embrace change and, in the best case, be involved in shaping it. But that's easier said than done.

40 %

of all new jobs created between 2005 and 2016 were in **areas with high levels of digitalization.** The problem: 6 in 10 workers worldwide do not even have basic computer skills. This is another divide showing that continuous education is an increasingly important admission ticket to the labor market

Source: OECD

» Digital transformation hinges on acceptance by the entire workforce

As a result of digitalization, many things can be done at locations other than one's regular place of work. Jobs are being flexibilized. Will the importance of the office tower decrease?
The organization as the social connecting link is still in vogue. There's nothing more important in daily working life than personal exchange. The fact that the workplace and its design are receiving a different quality with short business channels, less silo thinking, and optimal means of communication for cross-functional and cross-location exchange is a positive development. The reason for Silicon Valley's success for instance lies in the fact that people seek to be in close touch with and talk to each other. We're seeing this in the new work methodology in software development, experiencing it in small start-ups, as well as in small and medium-size companies, but not yet in all large corporations.

In day-to-day work, algorithms and machines are increasingly taking over decision-making processes. Are we progressively moving down the chain of command?
I'd caution anyone to have too much faith in technology – most machines and algorithms are not as intelligent yet as we always assume them to be. Most of the things we delegate to them are routine tasks. However, algorithmic assistance systems are gradually beginning to play a part in more complex decision-making processes, for instance in HR recruiting using diagnostic tools. Plus, in the future, there'll be fewer checking and control processes by humans. Systems in industry such as predictive maintenance and condition monitoring automatically detect problems and reduce defects. However, the higher-level tasks of process control, communications, coordination and improvisation cannot be delegated to machines. In aviation, for example, many systems today are already running autonomously but especially the most recent air disasters have shown that it will continue to be necessary for pilots and air traffic controllers to keep an eye on everything and be able to intervene in critical situations. We should therefore look at algorithms and machines as tool, but not believe that they can make entire decisions and ultimately even think for us.

Will the day come when humans are able to view robots and AI as equivalent colleagues – or even accept them as bosses?
We tend to ascribe human traits to machines and programs in order to humanize them, but robots and cobots only execute what they've previously been taught. They can neither think nor autonomously solve problems or develop emotions. That's why I think that's nonsense.

What do you think of the idea of classifying robots or computers as "electronic persons" and to require their owners or operators to pay separate taxes for them?
We shouldn't discuss additional taxation of capital expenditures because that's actually what taxation of robots would amount to. When we're discussing tax reforms it would be better to think about raising taxes for specific corporations – especially the major internet companies – and closing tax loopholes.

The interviewer

Project tasks, changing clients, remote work: **Oliver Jesgulke,** who conducted the interview, has already arrived in the new working world. Although he's not sitting on a beach in the Caribbean digital tools have been enabling him since 2012 to optimally combine work and family life as a freelancer. The fact that he practically just knows the grueling rush-hour traffic in Berlin from hearsay is a positive side effect.

Neo jobs in the world of tomorrow

Artificial intelligence, quantum physics and robotics will dramatically change our world this century – including the world of work. Some jobs will disappear while others will emerge. This is what such neo jobs might look like.

By Wolfgang Karg

Jobs in the city of the future

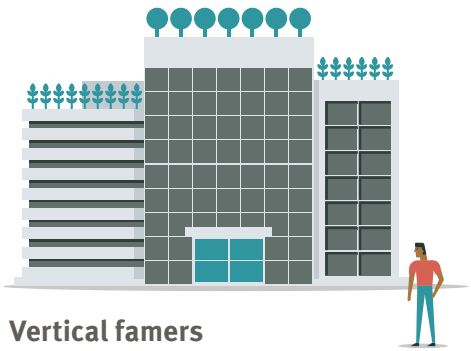
Urbanization is a megatrend: By 2100, the UN expects eleven billion people living on Earth, 85 percent of them in cities. New jobs will emerge to create the requisite infrastructure.

Smart city architects

A lively and livable city is like an organism. It involves a lot more than individual buildings, but requires effective interaction between them, transportation systems, water grids and power grids. Everything has to be connected to the Internet of Things and to IT worlds. **Since this involves the entire existing infrastructure, specialized architects will have to fuse old and new structures, real worlds and data worlds into a modern smart city.**

Traffic controllers 4.0 and drone crews

Preventing total gridlock in cities will be the job of traffic controllers and they will no longer primarily focus on above-ground roadways, train tracks and waterways with a few bridges and tunnels. **Urban mobility will increasingly be shifted into subterranean and airborne transportation systems.** Therefore, smart connectivity and control of transportation using new technologies will be a key skill for smart cities. Experts expect one billion passenger or cargo drones traveling in the airspace by the early 2030s. Many of them will fly autonomously, but many others be controlled by pilots. This is one example of a neo job, just like the requisite ground crews. Other new mobility concepts such as supersonic Hyperloop trains will create new jobs, too: in engineering as well as in operating them.

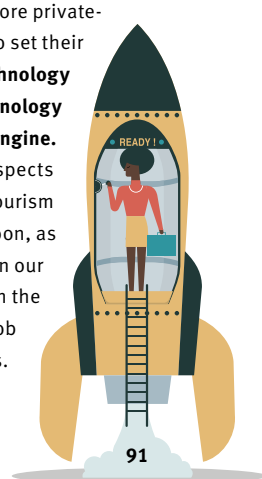


Vertical famers

Urban farming is not necessarily a contradiction in terms. Greening the roofs of buildings with edible plants has been around for a while. **The use of artificial light and fertile soil on the stories of skyscrapers, in former underground garages or on the walls of patios for urban farming is evolving into a serious business model in the world's growing megacities:** a new sector that might offer job opportunities not only to well-trained experts but also to people with lower skills.

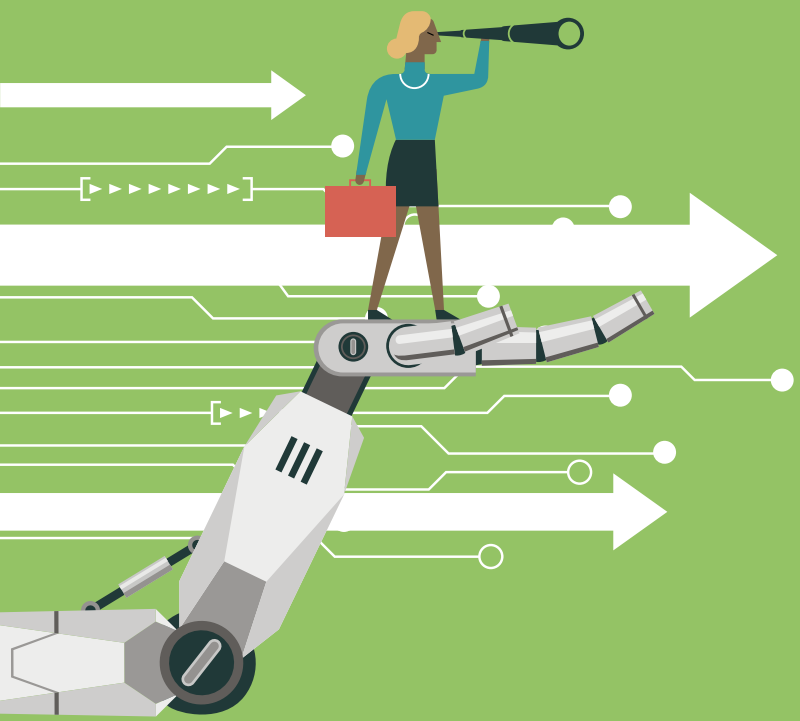
Space workers

Cities beyond the Earth's atmosphere are still science fiction at the moment – but how much longer? 50 years after the first lunar landing, space travel has picked up new momentum. Besides government agencies, more and more private-sector organizations have begun to set their sights on outer space. **Space technology might soon become a technology pacemaker again – and a job engine.** Especially since all-new business aspects are moving into focus: high-priced tourism in the Earth's orbit or on the Moon, as well as raw material exploration on our planet's natural satellite and in the asteroid belt will translate into job opportunities for space pioneers.



Life and work in the data world

Data are said to be the new gold. Even though machines capture, store and analyze them, humans will also profit from the new "gold rush" in the form of new jobs: for instance in the fields of data security, data utilization, and data marketing or sales.



AI specialists

Artificial intelligence creates a cornucopia of new activity fields to be occupied by humans: Obviously, they include programmers and experts that teach AI users. In addition, there will be specialists delving into program codes written by AI, whether for verification and control or for adaptation. **Moreover, people will be linking AI with existing professions such as AI artists, AI film producers and AI musicians.**

Cryptocurrency bankers

Digital means of payment use sophisticated algorithms for financial transactions. By now, several thousand cryptocurrencies exist worldwide and in many countries they're no longer just niche assets. Facebook's announcement of launching the Libra cryptocurrency will attract other providers. **Investment consultants specializing in cryptocurrencies are going to profit from this trend.**

Personal data traders

Even at this juncture, all of us produce huge amounts of data: with every purchase, every use of transportation, and every click on a website. These data have tremendous value and at the moment, we, their producers, are still giving them away. **In the future, personal data traders might be converting the virtualized information of individuals or groups into cash.** And, like in any business environment, there's potential for conflict. This is where data protection attorneys would come into play. The question of what data may be collected in the first place is explored by data ethicists and when data are freely traded, specialists can make a lot of money by tapping into new sources.

Virtual morticians

What will remain in data networks after death? Who will erase personal files, posts and photos that are not meant for eternity? Handling the digital legacies of individuals, companies and institutions is a job for specialists. **Virtual morticians take care of the things that are intended to remain and those to be deleted in digital networks** because the right to be forgotten is becoming increasingly important in the age of social media.

Forensic data scientists and data detectives

What traces am I personally leaving behind in data networks? Who has access to my data? Where do companies have data leaks that need to be closed? Who manipulates cryptocurrencies? **All these questions require specialists in data forensics who answer them with a detective's investigative skills and the use of AI:** a future-proof job because crime never sleeps in cyberspace either.

Workers in virtual worlds

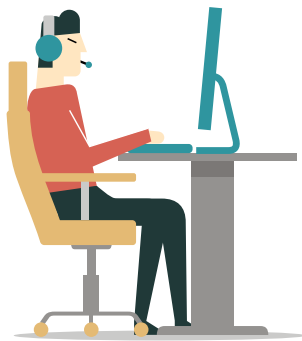
Computer-generated worlds are becoming increasingly realistic. More and more new business ideas are emerging with unusual job profiles in tow – and many of them are also related to more traditional fields.

Virtual travel planners

Travel planning is another business segment for virtual worlds. Smart glasses available at a growing number of travel agencies make it possible for clients to explore hotels, hotel rooms, resorts or cruise ships before booking a vacation. **Such virtual discoveries have to be developed and produced,** which not only requires computing power but also human creativity. And why not opt for virtual travel in the first place? Virtual worlds '"feel" increasingly authentic and virtual travel planners could customize perfect trips for their clients from a continually growing offering.

E-gamers

Is this a sport or mere gaming? The seriousness of e-sports and e-games has been debated for some time – and actually been decided when looking at the burgeoning interest in them. **E-gaming and e-sports pros have begun to make quite a bit of money from the worldwide video coverage of their competitions held in sports arenas.** As in traditional professional sports, many job opportunities are emerging here: from coaches to physiotherapists to sports marketers and sponsorship agents. Plus, the virtual arenas have to be built – by VR architects.



VR architects

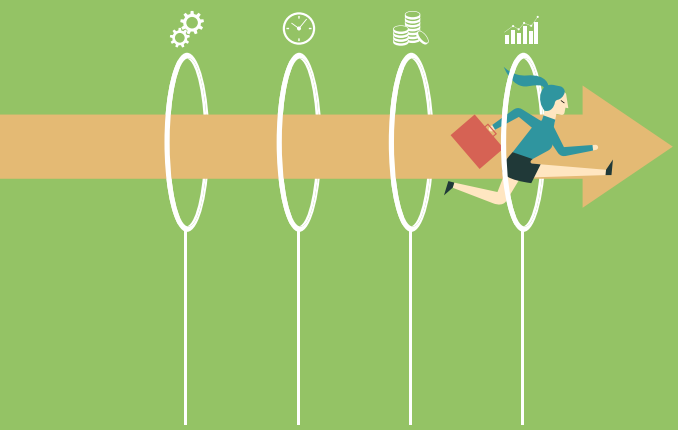
Ultimately, virtual spaces are – spaces. And who are the people that specialize in building spaces? **Architects and interior designers.** Consequently, these professionals are in demand in virtual worlds as well, albeit with emphasis on different skill sets. After all, their architectural projects do not involve brick and mortar but ones and zeros. However, a knack for form, color, structures and functional features is as important in the virtual world as in the real one.

New jobs focused on people

Aside from new technologies, people and the environment will take center stage in the professional world of tomorrow. Recreational activities, education and health are three fields with huge potential for jobs.

Life coaches

People are living longer and longer, are more affluent and have more free time. However, life is also becoming increasingly complex due to the digital flood of information and diversity of offerings. **So-called life coaches help us master our everyday life and free time:** in the fields of mobility, health, nutrition, fitness, knowledge or even in the context of anti-aging and more.



Genetic engineers

Manipulation of the human genome as well as that of animals and plants will continue to be a controversial subject – but is far from having been fully exploited. **New forms of jobs will not only emerge in scientific research, technology and medicine but also in the fields of ethics and legal advice.**

IoT connectors

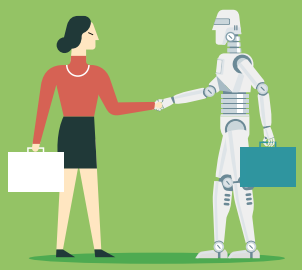
How can people connect themselves to the Internet of Things? How can they derive the greatest benefit from the resulting opportunities? **IoT experts in the fields of health, household, hardware and software, and training provide relevant assistance.**

Educational portfolio optimizers

The technology-driven transformation of the working world provides people and companies with a growing number of new opportunities. **The job of educational portfolio optimizers will be to make the most sensible selections from the worldwide offerings for individuals, groups or companies.** Not every training opportunity is suitable for every individual, so making smart choices will become increasingly important.

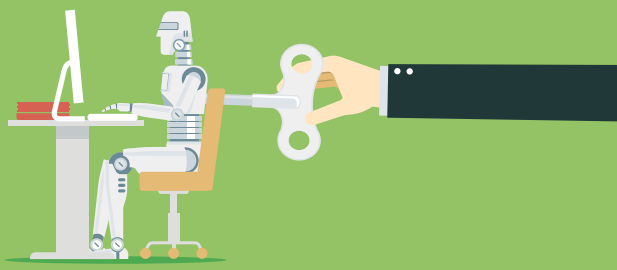
New forms of work in future factories

Industry 4.0 is making headway. Machines become interconnected in the Internet of Things. This results in many new jobs, especially at the interfaces with robotics and artificial intelligence.



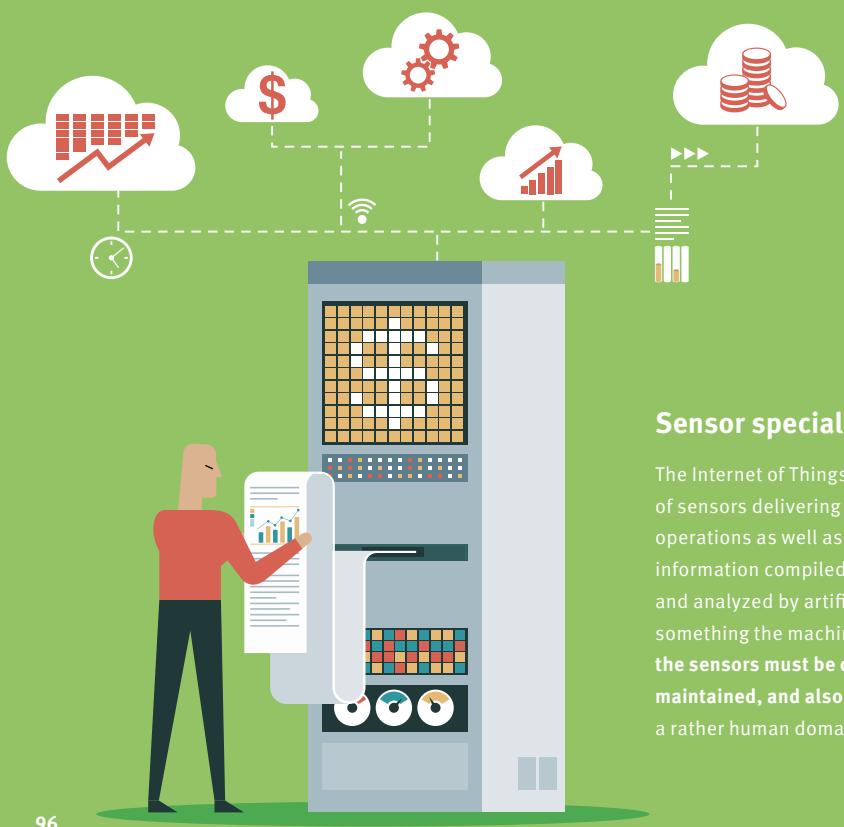
Human-machine teaming managers

In Industry 4.0, teaming managers assist in coordinating humans and machines. The objective is to avoid errors due to the differences in human and machine logic. For successful companies, it will be crucial to ensure that humans and smart machines learn to understand each other and form a team. Empathy trainers explaining the world of emotions to machines can also assist in this process.



Robot mechanics

Machines designing and building other machines are nothing new. In the future, smart machines are going to develop and produce other smart machines. **However, if the use of a robot causes problems in the production process, humans will still be superior in performing repairs for a long time.** Human power of persuasion will also continue to score when it comes to selling robots.



Sensor specialists

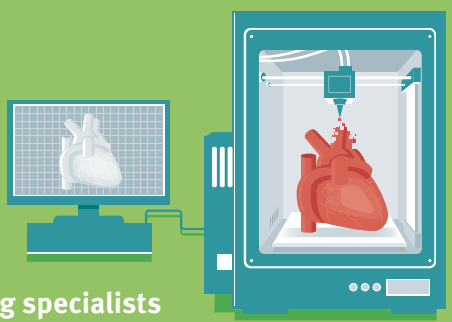
The Internet of Things will consist of billions of sensors delivering data – in manufacturing operations as well as in everyday life. The information compiled by data mining is evaluated and analyzed by artificial intelligence. This is something the machines can do without us, **but the sensors must be developed, positioned and maintained, and also sold to customers.** All of this is a rather human domain.

Blockchain managers

Manufacturing and logistics processes in Industry 4.0 are supported by blockchain technologies. **Specialized managers plan, implement and analyze them using AI.** Blockchain technologies might also develop enormous job potential in the area of data security.

Algorithm insurers and lawyers

Computer programs increasingly control process flows in the working world and in everyday life. That's great as long as everything works the way it should. But as soon as faults emerge and result in loss or damage, questions of liability and compensation emerge. Who will be held responsible? The programmer? The robot's manufacturer? The company that uses the robot? **In the future, specially trained insurance experts will have to answer such questions.** Equally interesting is the legal aspect of such liability issues, which requires specialists as well.



3D printing specialists

Plastics, metals and even biological substances can be shaped in nearly any conceivable way by means of decentralized 3D printing. This changes the development and manufacturing of products as well as the procurement of assembly components and spare parts. **A growing number of 3D printing specialists is constantly developing new methods, materials and components.** Checking 3D models, files or designs could be a service with high future potential. The artificial production of foodstuffs, and even of organs, is another field that is seeing massive development.

The author

Besides classic literature books, author **Wolfgang Karg** read a number of science fiction novels in his youth. Technologies for the future are also his main topic as an internationally active science author and keynote speaker. Even though many future technologies seem to be predictable at this juncture, he's convinced that many things won't turn out the way we're expecting today.

Masthead

Published by
Schaeffler AG
Industriestraße 1–3
D-91074 Herzogenaurach
www.schaeffler.com

Schaeffler Communications
Thorsten Möllmann
(Senior Vice President Global Communications & Branding)
Martin Mai
(Head of Newsroom, Global Editor-in-Chief Schaeffler Group)

Editor-in-Chief
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Editorial Team and Production
Speedpool GmbH

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Graphic Design
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Gökhan Agkurt,
Ivo Christov, Janina Roll,
Julian Schmaljohann,
Thomas Wildelau

Printing
Hofmann Druck Nürnberg GmbH & Co. KG

An innovation of the Schaeffler subsidiary Elmotec Statomat GmbH: **stator with flat wire** for high-performance drives in electric and hybrid vehicles as well as for alternators

Authors
Wiebke Brauer, Björn Carstens, Denis Dilba, Oliver Jesgulke, Wolfgang Karg, Lars Krone, Carsten Paulun, Bettina Schuller, Dr. Lorenz Steinke, Roland Zumsande

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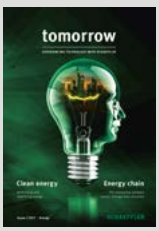

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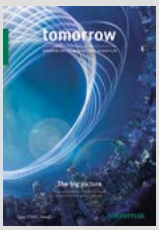

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