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# ESSENTIAL

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FREUDENBERG SEALING TECHNOLOGIES  
THE MAGAZINE – ISSUE #2 2017

DEPARTING  
FOR NEW LANDS  
IN SEARCH  
OF NEW  
HORIZONS

## DEPARTURE

Everything is possible, everything is open: On the opportunities at the outset and for a fresh start

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### THE OPTIMISTIC BRAIN

Neuroscientist Tali Sharot on our urge to see everything as optimistically as possible

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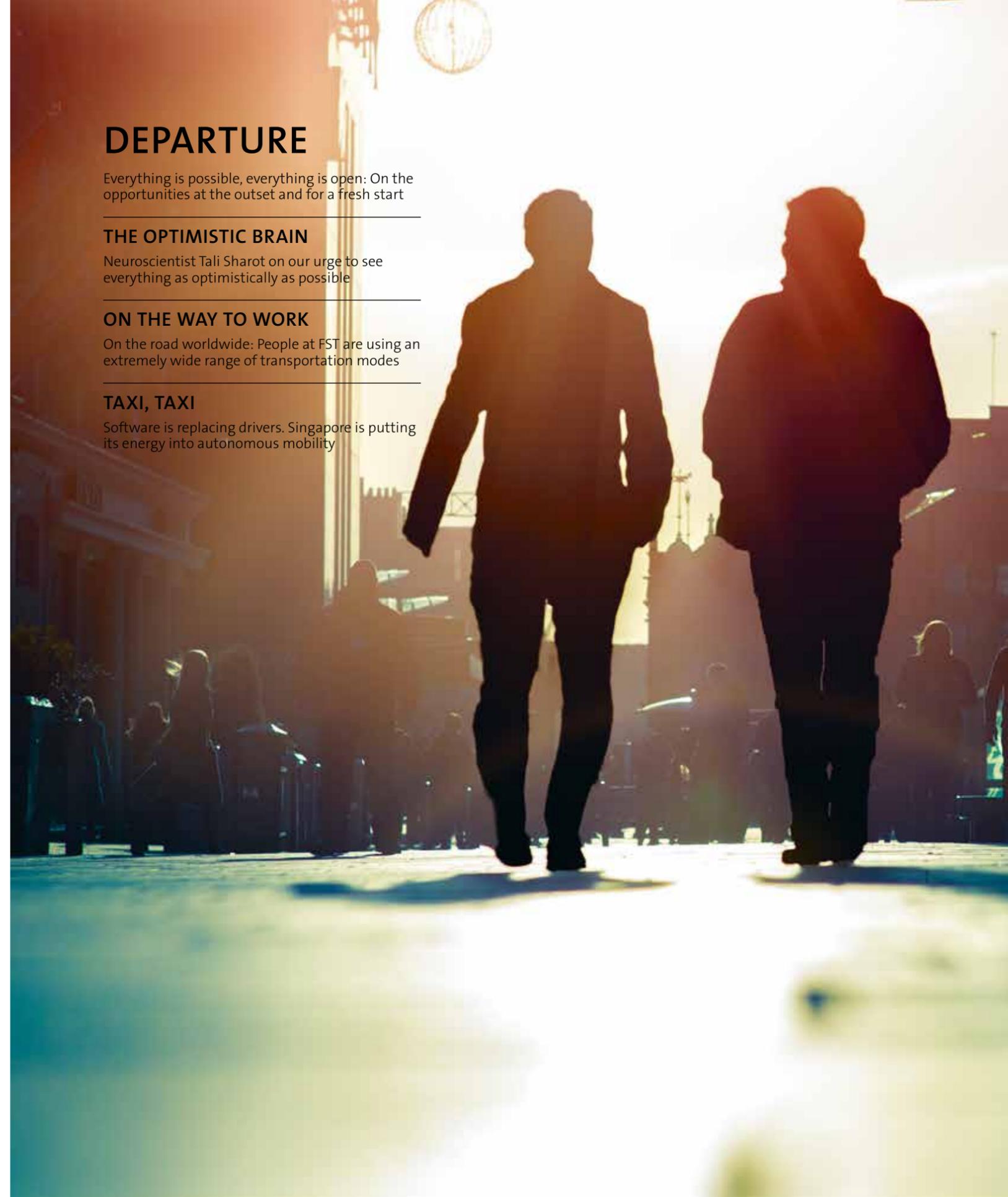
### ON THE WAY TO WORK

On the road worldwide: People at FST are using an extremely wide range of transportation modes

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### TAXI, TAXI

Software is replacing drivers. Singapore is putting its energy into autonomous mobility



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# DEPARTURE

The wanderer at the start of his journey. Humanity before it reaches for the stars. Science or industry on its way into a new age. A “departure” always combines a variety of emotions and expectations: pleasure at the prospect of discovering something new and unexpected. A pioneering spirit. A freedom to discover. But uncertainty about what lies ahead as well. If you are departing, you may know the destination, but you cannot know what actually awaits you.

The dictionary has various “characteristic word combinations” for departure: hopeful departure, social or cultural departures, forcing a departure, risking a departure. An atmosphere of departure. Departure, renewal, upheaval. There is doubtless something poetic about a departure, something fundamental. A departure begins with the first step, but first you have to take it. A departure simultaneously harbors the potential to experience something great.

Where is the future headed? What awaits us as human beings, as a society, as industrial creators? Questions that have occupied humanity in one form or another from the very start. In fact, based on everything that we know, humans are the only species on earth that can travel mentally into the future. This is invariably only of limited help in actually answering our questions. The future remains an uncertain mystery into which we all project our desires and hopes. In ancient times, people

expected answers from helpers such as the Oracle of Delphi. In the 21st century, “future research” has established itself as a science, above all because researchers understand there is not just one future – but many possible future scenarios.

Digitalization, automation, new forms of powertrains – this triad is one of the most cited visions of the future in the industrial sphere. It lies right before us. In each instance, we have been in a state of departure for a long time. The technologies are developed, the basic research is complete, prototypes are being tested. And everyone still feels that more is on the way. Or to return to the image of the journey, our rucksacks are packed, and the potential destinations are marked on the hikers’ map.

But do we really know where it taking us? In Kafka’s short story, “The Departure,” the servant reminds his master that he hasn’t packed any provisions. The answer was, “I don’t need any.” The journey was much too long for provisions, he said. “Fortunately, the trip is truly immensely long.”

The right portions of daring, optimism, and a willingness to take risks are the ingredients of an authentic departure. Before a daily trip to the supermarket, no one would loudly proclaim “I am now departing!” A departure is the opposite of routine. It is something for explorers, visionaries and the enterprising. The word “undertake” includes the word “take.” In the truest sense of the word, departure means a chance to grab something with both hands. All the major engineers, industrial pioneers and successful business people of our time have departed on a journey of this kind.

Here is a feeling that many successful entrepreneurs, explorers and inventors would share: The greater the challenge, the more fulfilling the journey. For the most part, the people who take us by the hand and guide us into the

future – whether to electric propulsion or to the self-driving car or on a trip to Mars – share a dash of self-confidence, an unshakable belief in the success of the journey, and a positive sense of the future.

It’s always good to have a partner, a like-minded soul, when you depart. But sometimes departure means leading the way. Such a departure into uncertainty is too much of a risk for the timid. Those who depart exhibit foresight, courage and determination.

All you need to do is take the first step – a step that could be the start of a great future. ©



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# ENERGY OUTPUT

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In the Jules Verne novel "Around the World in 80 Days," Phileas Fogg circumnavigated the earth by train, ship and all kinds of other transportation. But Fogg never resorted to a bicycle. Last summer, Scot Mark Beaumont showed that it was possible to ride a bike around the world in 78 days. The endurance athlete cycled from Paris to Beijing via Moscow, through Australia and New Zealand, from Alaska to Halifax, and finally from Portugal back to Paris. He only traveled by air over oceans. After 78 days, 14 hours and 40 minutes, he had managed to cover 29,000 km (18,000 miles). During this period, he consumed 9,000 calories per day and got along with just five hours of sleep per night.

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# INSTINCT

Every year, tens of thousands of emperor penguins set off on the same journey. In April, they leave the nutrient-rich waters of the Atlantic for their breeding grounds on the Antarctic ice. In the process, they defy snowstorms and temperatures down to  $-60^{\circ}\text{C}$  ( $-76^{\circ}\text{F}$ ). As soon as their offspring mature in their eggs they make their departure – a cycle they will repeat again and again. They travel back to the ocean to gather food for their young. Taking turns, the emperor penguin pairs migrate back and forth a total of 16 times. Researchers have calculated that each animal takes on a distance of up to 2,000 km (1,250 miles).



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# PROGRESS

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Even as late as the year 2000, three-quarters of all information was stored on analog data carriers. Not even one generation later, the idea seems very quaint. Today more and more people are storing their data in the cloud, since most information is now received and processed digitally. Industry 4.0 is based on digitally connected facilities and products. All of this generates huge quantities of data. Big data successfully handles processing with the help of better performing and smarter machines. Managing and interpreting the flood of data is becoming possible, and more and more knowledge is available. Humanity is beginning a new chapter.

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## “OPTIMISM IS VITAL”

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Israeli neuroscientist Tali Sharot has shown that people tend to paint the future a bit rosier than it is actually going to be. In an interview with “ESSENTIAL,” she explains why that makes sense – why our brain often deceives us, and how we make our decisions before heading out into the unknown.

#### MS. SHAROT, IS ANTICIPATION OF A POSITIVE FUTURE SOMETHING DEEPLY HUMAN?

At least in some cases, it feels even better to expect something good than to actually experience it. Experiments have shown that people would pay more for a kiss from a celebrity if it were to take place in a year's time than if they were to receive it immediately. An immediate kiss allows no time for anticipation.

#### IS THAT WHY A NEW BEGINNING, A DEPARTURE, PUTS US IN SUCH A POSITIVE MOOD?

Yes, because everything is open to us. There are no boundaries. We can imagine the best possible outcome and we tend to do precisely that subconsciously.

#### SO HUMANS ARE WIRED TO THINK POSITIVELY.

Yes, that can be shown in various ways. [An overwhelming majority of us expect things to be more positive than negative for us in the coming month](#), no matter how old we are, what population group we belong to, or what our economic status is. We believe that good will happen to us and we underestimate risks. But just for us – not for others. The number of criminal offenses is usually imagined to be higher than the total actually committed. But practically no one expects to be the victim of a crime. We overwhelmingly tend to appraise ourselves as more interesting, friendly and successful than the “average.” But it is just mathematically impossible for 93 percent of us to be better drivers than the rest. But we are

often not even aware of this inclination to optimism. That's exactly what makes it so powerful.



#### THAT SOUNDS A LITTLE UNSETTLING.

It is normal and probably vital. Based on everything that we know so far, we are the only species that has the power to consciously project and to travel into the future in thought. But that has a price; it is associated with the knowledge that death awaits us, along with old age, illness and the decline of our capacities. Fear and worry about this would necessarily cripple and constantly compromise us in our everyday life. Without repressing such negative forecasting, the capacity for projection would likely be an evolutionary dead-end.

#### SO WE ARE GENERALLY NOT INCLINED TO BE PREOCCUPIED WITH NEGATIVE NEWS.

Yes. In one of our experiments, we invited participants to a lottery: either a large or small monetary prize was selected for them by chance. They had previously been allowed to look behind one of two doors to see what was hidden – but this did not change the result. Again and again, people chose the little door with the more valuable prize. That shows us that we want to know what luck could have in store for us in the best case, and not the disappointment that could await us. You see the exact same thing among investors when they look at their stock portfolios: if the share price is rising, they log on more frequently to get a good feeling. If the share price is falling, many turn a blind eye.

#### SO YOU ARE MAKING THE CASE FOR OPENING THE DOOR TO THE BAD NEWS MORE OFTEN?

We humans are more resilient than we think. If we open the door, we can begin to accept, and that also means recovering and starting anew. Sometimes we believe that it's better not to know. But that just makes us more anxious. But that's not advice that applies everywhere and at all times. Think about medical prognoses and precautionary tests. Something like this is very helpful if the disease is curable or if you could infect others. But it can be a source of unnecessary stress if you know you are suffering from a fatal disease and can't do anything about it. Incidentally, this is a decision that we will likely have to make much more often in view of medicine's progress

## “DIE MEINUNG DER ANDEREN” SIEDLER-VERLAG, 2017

In her latest book, Tali Sharot delves into the question of how we are influenced – and how we affect others. Based on her own psychological and behavioral economic studies, the neuroscientist shows, on the one hand, why it is so difficult to persuade someone to change his thinking, and, on the other hand, why we often don't even notice how fully we allow ourselves to be subconsciously influenced.



#### IN THAT LIGHT, IT EVEN SOUNDS LIKE A SENSIBLE EXCHANGE.

Yes, there is a whole series of examples of people acting in a way economists would call irrational, and I now have my doubts as to whether this is true. We do not merely act to optimize our finances and our material things, but also to optimize our emotional balance and our mental health. If we are happier and, in the process, make do with a little less money – why not? Naturally, it doesn't necessarily help your frame of mind when you lose large sums of money.

#### BUT THE CONTROL FEELS GOOD.

We are designed to maintain control over our environment ourselves. There are good reasons for this: by and large, making the decision ourselves leads us to a better result. That's why enormous stress results when the power to make decisions is taken from us. Incidentally, our fear of flying is based on the fact that we have no control at these moments.

#### FROM THIS STANDPOINT, IT IS SATISFYING TO MAKE A DECISION, NO MATTER WHAT IT IS, BECAUSE IT GIVES THE PERSON CONTROL OVER HIS OWN ACTIONS.

That is an interesting thought. Yes, facing a decision is uncomfortable. You juggle a thousand things in your head, and every vision of the future harbors the fear of loss. If I decide this, I can't have the other thing. But as soon as I make the decision, I can push all that aside and put my mind in order. This then leads to a situation where you evaluate a decision more positively once it is made than during the decision-making process.

#### IMAGINE THAT WE ARE AT THE START OF THE PATH. EVERYTHING IS NEW. NOTHING SEEMS IMPOSSIBLE. HOW AND WHY DO PEOPLE MAKE DECISIONS?

There are some interesting findings on this. When we have to make the same decision multiple times, we keep tapping into different knowledge. So our choice can turn out differently every time. Should I take this job offer or would another be better? If I choose this, I lose that. This or that apartment? Again and again, there will be other details that steer you in one direction or another. We have a great deal of knowledge stored away. We cannot call it all up at the same time.

#### WOULD PEOPLE WANT TO MAKE DECISIONS THEMSELVES?

It is known that professional fund managers are able to handle your finances better. Still, many people are more comfortable managing their own money. Here we are exchanging financial profit for peace of mind.

### JUST THE FACT THAT WE MADE A DECISION ON SOMETHING IMPROVES OUR ASSESSMENT OF THE DECISION?

We have shown this in the lab and presented people with two possible vacation sites: Thailand and Greece. With some trickery, we made the participants believe that they had deliberately chosen one of these countries. In reality, the choice that we presented was purely coincidental. Nonetheless, all of them justified the decision they had apparently made in great detail and then liked one travel destination measurably more than the other. This confirmed similar experiments by other researchers who asked their subjects, for example, to choose the more attractive of two people. But after many, many different rounds with several hundred images, the participants then were presented with the opposite choice in each case, without realizing it. The result was a quick, very detailed and flowery justification as to why the subject found one person – whom he had previously rejected – to be more attractive.

### SO WE FIND JUSTIFICATIONS FOR DECISIONS AFTER THE FACT MERELY BECAUSE WE BELIEVE THAT WE MADE THEM?

Yes. But the following applies here as well: this mechanism helps us to move forward. Otherwise we would stagnate. We make a decision – so we are doing something. That doesn't necessarily mean that we won't regret it later in some cases.

### NONETHELESS, IT GIVES ME A QUEASY FEELING TO IMAGINE THAT MAJOR DECISIONS IN INDUSTRY, TECHNOLOGY AND POLITICS ARE LATER JUSTIFIED VEHEMENTLY, EVEN THOUGH THEY MAY HAVE RISEN FROM COINCIDENCE.

Every bias, that is, every cognitive distortion by our brain, has an origin, an evolutionary significance, and offers a certain advantage. But it can also have negative effects. This is just a basic constant in our lives. Everything has two sides.



### HOW IMPORTANT IS THE PAST WHEN WE MAKE DECISIONS?

Very important. It is the building block for looking into our future. It has an impact on how we envision the future. Not just our own past but also the experience of other people. You can't create something out of nothing. Even if we believe we are at the start of a journey, and everything is new and free like a blank sheet of paper. In reality, everything is based on past experiences.

### SO THERE ARE NO COMPLETELY NEW, FREELY-MADE DECISIONS?

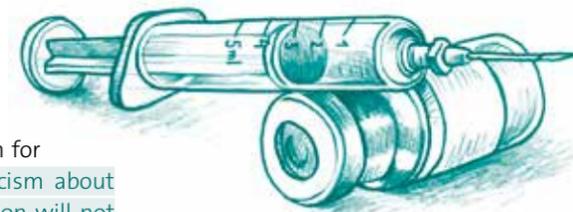
It is through learning and experiencing that we first become what we are. A baby begins learning as soon as it is born. Only a few reflexes are inborn. The remainder is learned through trial and error, from the first movements all the way to speech. All the attempts to create artificial intelligence are based on the same principle: trial and error, independent learning. Decisions are based on prior experience.

### AND ON CONVICTIONS, AS YOU PRESENT IN YOUR NEW BOOK, "THE INFLUENTIAL MIND."

In our lives, we all develop a very strong set of opinions from which we only allow ourselves to be dissuaded with great difficulty. Religion is often an example. Politics is another. When we are very convinced of something, we often don't let ourselves be dissuaded by facts. On the contrary: we look for logical errors in the facts or develop new counterarguments based on them. Paradoxically, any attempt to change our minds leads us to be even more convinced of what we previously believed. It is a phenomenon that is currently a source of amazement in many political discussions.

### THAT MEANS WE ARE ACTUALLY INCAPABLE OF LEARNING NEW PERSPECTIVES?

Oh no, we can definitely learn. But if you are very convinced of something, then I have a hard time countering the conviction with facts because it is tightly intertwined within you. In a way, every doubt would call your identity into question. It is more promising to question the actual motivation for your conviction and then address it. Take skepticism about vaccines as an example. An opponent of vaccination will not change his opinion in response to statistics that show no connection between vaccinations and autism. But what actually is his deep-seated motivation? Fears for the child to be vaccinated, in all likelihood. So it is more promising to argue, "Hey listen, vaccines protect your kids from these deadly diseases." Vaccination opponents really don't dispute this. Instead of attacking an existing conviction frontally, it can be better to find common, unifying motives.



### HOW IMPORTANT IS IT TO PEOPLE TO BE ABLE TO INFLUENCE OTHER PEOPLE?

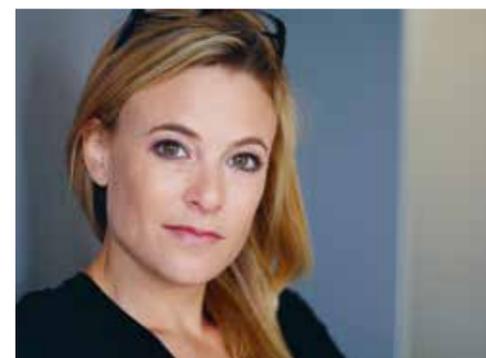
Immensely important! Without Kennedy's stirring speech, we might not have gone to the moon. Individuals can persuade people on very rational as well as quite unreasonable things – I am sure a few examples occur to you straightaway. Naturally, we realize after a while that one idea or another was nonsense. Think about the biotech sector, which in the past was supported with millions of dollars, even though the basis for all of the ideas was not demonstrably strong.

### DOES IT HELP TO KNOW HOW OUR BRAIN RESPONDS? YOU'VE DESCRIBED HOW HUMAN MANY OF THESE PROCESSES ARE. DO YOU BEHAVE DIFFERENTLY IN YOUR EVERYDAY LIFE?

I think it is good to have them in the back of your mind, at least. For example, the fact that you get further by offering people alternatives and letting them choose. I at least try to think about this in raising my children. I deliberately choose positive statements: "Tidy your room so you can find your favorite toy more easily." That works better than threats. Well – most of the time.

### IF WE TAKE ALL THIS INTO ACCOUNT, DO WE DEVELOP AN OUTRIGHT FEAR OF OUR OWN BRAIN? CAN WE REALLY TRUST OURSELVES?

The brain is all that we have. There's nothing else to trust. It is certainly not a bad idea to occasionally be skeptical about the first intuitive idea that comes to mind and to think about it. But in the end, there is nothing better to trust than our own brain. ©



TALI SHAROT

Sharot, an Israeli, earned her doctorate in psychology and neuroscience at New York University and is a professor at the Institute for Experimental Psychology at the University of London. In addition, she directs the Affective Brain Lab, which investigates how affects and emotions influence our perception and behavior. She also does research on memory, optimism and decision-making. Her book, "The influential mind," was awarded the British Psychological Society Book Award. The video of her 2012 Ted talk has already been viewed 2 million times.



Find the entire TED Talk with Tali Sharot online at <http://bit.ly/1ge0Int>



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# ON THE WAY TO MARS

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Mars fascinates humanity. But people today are not as concerned with whether there is life on Mars as they were in the past. Instead, they are concerned with how life will get there. The plans for a departure to Earth's neighbor are taking on increasingly practical forms.

Mankind has chosen Mars as the next major destination for manned spaceflight. But what is waiting there doesn't sound especially alluring. The desert-like planet has an average temperature of  $-60^{\circ}\text{C}$  ( $-76^{\circ}\text{F}$ ). It lacks a magnetic field to protect it from aggressive cosmic radiation. The atmosphere is just one-hundredths of the Earth's, and oxygen or liquid water are not among the planet's attractions.

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## MAKING THE CASE FOR MARS

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But there are good reasons why humanity is looking at Mars as "Planet B." Martian rocks are rich in resources. Its day is close to the usual 24 hours. If it became warmer, it could reform an atmosphere itself and melt the available ice. The abundant carbon dioxide would promote the growth of plants. Since its gravitational pull is just one-third that of the Earth's, any heavy-lifting, in the literal sense of the term, would be easier. And, last but not least, the mission itself would no longer represent a huge challenge. The travel time to Mars will no longer be calculated in years but in months. SpaceX considers about three months to be possible. Conservative calculations range from six to nine months.

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## HAVING THE INFRASTRUCTURE BUILT

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The real challenge is enabling people to stay on the planet longer. One thing is clear: the goal is not to bring people to Mars and set them down for a short stay as they did with the moon landing, and then send them back to Earth. NASA's vision is to stay on Mars. That would require infrastructure to make survival possible in the first place. What should it look like? Will space ferries land on gravel tracks? Will the people in the Mars expedition live in inflatable tents?

As Senior Technologist at the Kennedy Space Center, Robert Mueller, has dealt with these and other issues. In the process, he and his team in the so-called "Swamp Works Lab" have zeroed in on applications from engineering. "We are specifically working on how we can construct an existing infrastructure on Mars, that is, landing sites, roads, hangars and living spaces that are protected from radiation." Would that mean that the astronauts would first have to become construction workers? "No," he says, shaking his head. "Autonomously functioning 3D printers would take over the work. We can direct their mode of operation from the Earth even if we have to allow for the transmission time, which is about 20 minutes." The printers would generate the energy that they need for their work from solar radiation.

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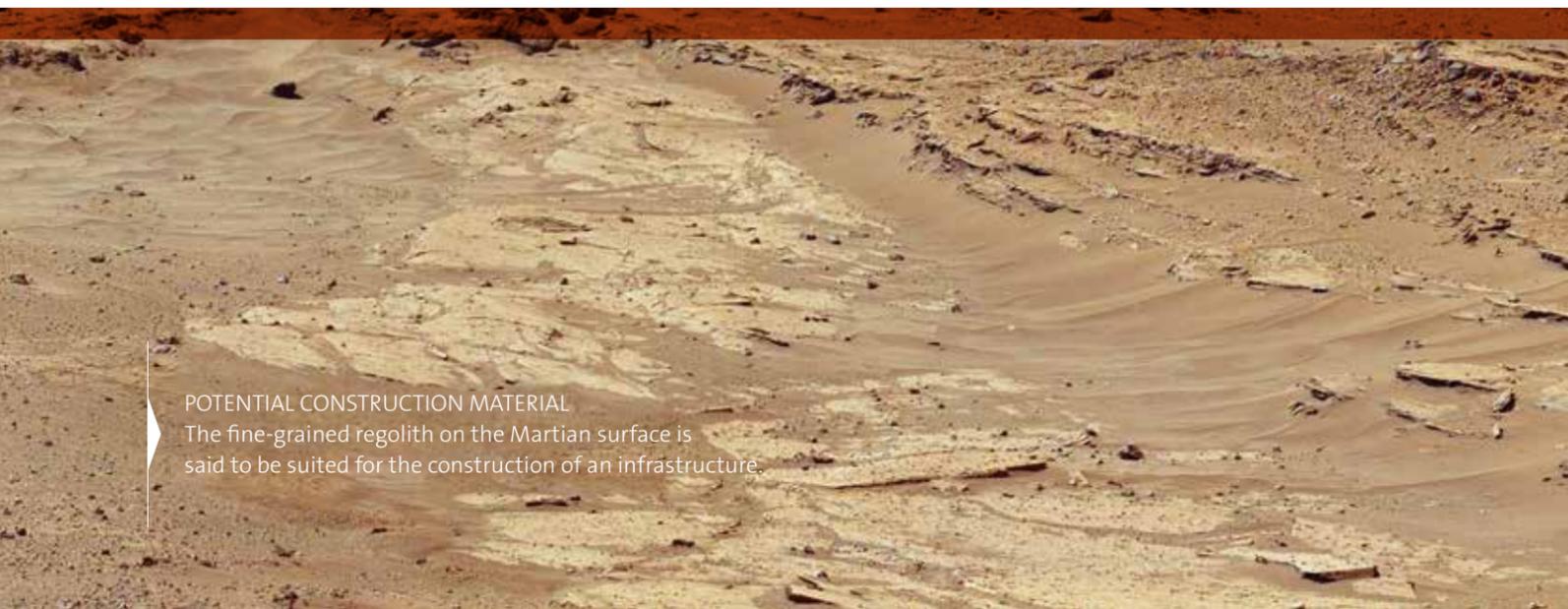
## CONSTRUCTION MATERIAL IN ABUNDANCE

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That leaves the problem of construction material. Space engineers have always been preoccupied with the cargo issue. The more cargo loaded on board, the larger the spaceship and the more expensive the mission. The solution is quite simple. "Why should we take construction material to Mars with us if there is already more than enough material there that we could use for 3D printing?" Mueller asks. To a great degree, the Martian surface consists of fine-grained regolith, which has accumulated due to weathering over the course of time. With the addition of the additives that are also available on the red planet, it is also superbly suited for the manufacture of an infrastructure that would be needed for life on Mars. Mueller and other NASA researchers are also working on robots to mine the regolith and transport it to a processing facility where it can be printed out as the desired component.



PUTTING IT TO THE TEST  
Three teams recently tested 3D printing processes that could be used on Mars.



POTENTIAL CONSTRUCTION MATERIAL  
The fine-grained regolith on the Martian surface is said to be suited for the construction of an infrastructure.

"Something entirely different can be produced from the material available on Mars: oxygen," Mueller says. "Many compounds there contain oxygen. If we manage to separate them in such a way that we get construction material on one hand and oxygen on the other, then we will have killed two birds with one stone."

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## DEALING WITH COSMIC RADIATION

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Cosmic radiation, which strikes the Martian surface nearly without impediment, would still be a problem. Some of Robert Mueller's colleagues at NASA are wrestling with the notion of erecting an artificial magnetic field between the sun and Mars. On its lee side, the red planet would be protected from solar winds, allowing a kind of greenhouse effect to conceivably become established. But Mueller believes it would be impossible to construct such a magnetic field. To provide protection from radiation, it would be much more practical to construct habitats among natural barriers that would keep out a portion of the

radiation. That would mean next to a cliff, crater or canyon. "If you were to cover the buildings with regolith, that would provide additional natural protection," Mueller says. "The influence of the radiation can be reduced even further if we use a polymer containing hydrogen as binder for the 3D printing of the buildings." Mueller and NASA are going to pursue these plans further. In the process, they are betting on the expertise of science and industry. In late August, in a competition organized by NASA, three teams showed how regolith can be used in 3D printing. The results were impressive and are another piece of the puzzle on the way to the colonization of Mars. That would truly be a giant leap for mankind. ©



Read more about the NASA project  
online at <https://go.nasa.gov/1L7yViT>



# A SOUTH KOREAN WINTER'S TALE

When the world's athletes meet for the Winter Olympic Games in February 2018, they will be entering new territory in the truest sense of the word. The kings of winter sport will be crowned in South Korea for the first time. The Asian host country has already transformed itself from a winter-sports nobody into a successful winter-sports nation at a rapid pace.



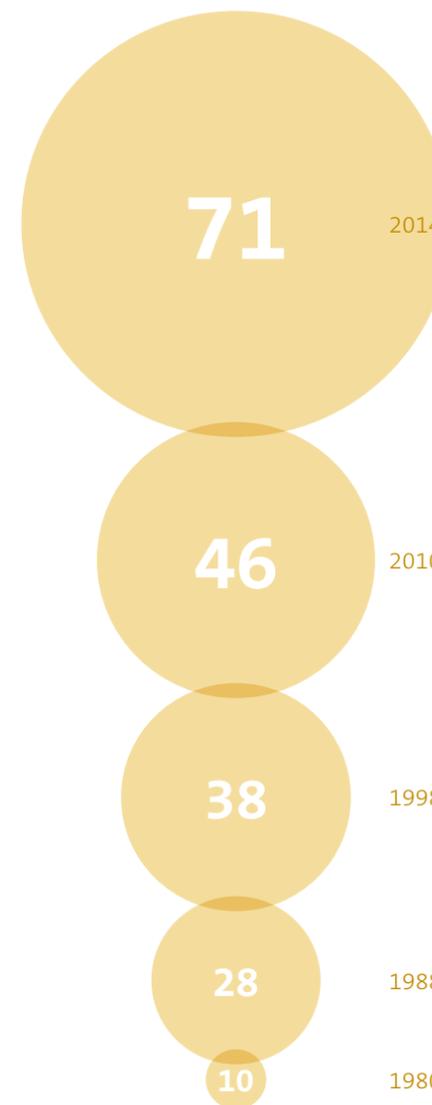
Back in the 1960s, South Korea was considered one of the world's poorest countries – and in 1999, it was already a member of the G20, the group of the most important industrial and advanced developing nations. Global brands such as Hyundai, Kia, Samsung and LG symbolize the rise of this East Asian country. South Korea moved at a similarly breathtaking speed on its path to becoming a winter-sports nation. Hosting the 23rd Winter Olympic Games in and around Pyeongchang represents the high point of its four decades of development.

## 26 OLYMPIC VICTORIES SINCE 1992

In the medal count for the winter games, South Korea now ranks thirteenth, just behind the traditional winter-sports nation France. It was only in 1992 that South Korea was awarded its very first Olympic medal. It has speed-skating and its younger sibling short track, which pits the athletes against one another, to thank for its 26 Olympic victories. An accomplished figure skater, Kim Yuna, joined her compatriots on the Olympic scene. She personally made the pitch for Pyeongchang before the International Olympic Committee (IOC) in 2011. "Many Korean winter athletes travel around the world just to train for their Olympic dreams. My dream is to share the opportunities I have had with other athletes. And Pyeongchang 2018 can help achieve that," she said.

## SKIING GUARANTEED

The successful awarding in 2011 also had an impact on sports participation. During the following winter, South Korean ski resorts had nearly 7 million guests. The country has merely mid-sized mountains by Central European standards. However, the ski areas are well-equipped and have good transportation connections. Starting in December,



The development of South Korea's team strength at the Olympic Winter Games

a high-speed railway is due to bring Seoul residents into the mountains in about an hour. The ski runs are also open at night. Hundreds of snow guns ensure good conditions even if there is a lack of snowfall. The same is true for

Yongpyong, where the first South Korean ski area opened in 1975. The total number has now reached 20.

## WILD RIDE

A mere four decades after the introduction of Alpine skiing, the sport has caught on here. The government and the people stood solidly behind the country's Olympics application. And this isn't just because of popular heroes on skates. Snowboarding has long been a hot trend among young South Koreans. And on skis, they are on the brink of reaching the sport's summit. Recently, South Koreans have been landing more often among the top ten on the mogul slope. The team is coached by Toby Dawson. The 38-year-old was born in Busan, South Korea, and was adopted as an infant by an American couple. In the 2006 Olympics, he brought home a bronze medal for the United States. He also advocated for Pyeongchang before the IOC. Now, as the national trainer for the South Koreans, he is promoting some significant goals – thanks to the country's Olympic tailwind. "My priority is to make the Korean mogul ski team one of the best in the world."

## IDOLS AND GOOD INFRASTRUCTURE

Even cross-country skiing could soon have a top South Korean contender. Magnus Kim, whose father is Norwegian and whose mother is South Korean, brought home gold twice in the Youth Olympic Games in 2016. At 19, he intends to be among the top 20 skiers in Pyeongchang. Athletes at his – and the now retired Yuna's – level have the potential to become objects of identification. Along with good sports facilities, they are an emblem of South Korea's powerful breakout as a winter-sports nation – one that plans to write a winter tale of its own in Pyeongchang. ©



# AS LUCK WOULD HAVE IT

A breakthrough in science and research can often be found at the start of new social and economic awakenings.

Years of work generally go into a new product or invention. But it is not always calculation and logic that are at the root of a far-reaching innovation. Sometimes accidents are the model, and they enable forays into entirely new dimensions in the first place. That's what these examples show.

## PENICILLIN

**Oh no:**

In 1928, British bacteriologist Alexander Fleming left staphylococcus lying in a petri dish in his London laboratory, and a mold, *Penicillium Notatum*, spread onto the bacteria culture while he was away on holiday for several weeks.

**Aha:**

Fleming saw that there was no longer any staphylococcus around the mold. An agent had apparently combated the bacterium effectively. Based on earlier experiments with pathogens, the eventual Nobel Prize winner recognized the importance of his discovery.

**Effect:**

At first, Fleming's findings went unnoticed – until Britons and Americans accelerated penicillin research and production during the Second World War. The agent emerged as a miracle weapon. It effectively combated gangrene, sepsis, diphtheria and other previously fatal illnesses. ©



## VULCANIZED RUBBER

**Oh no:**

In 1839, the American inventor Charles Nelson Goodyear experimented with a mixture of natural rubber and sulfur. Legend has it that he allowed the mixture to fall on a stovetop. Goodyear realized that the material suddenly acquired entirely different characteristics.

**Aha:**

The heating of the natural rubber-sulfur mixture led to its vulcanization. The result is known as vulcanized rubber. It has huge advantages over natural rubber, which becomes stiff and sticky in warm temperatures and brittle in cold temperatures. In contrast, vulcanized rubber is elastic, tear-resistant, and extremely stable.

**Effect:**

It is this vulcanized version that really gets industrialization rolling. Air-filled rubber tires sold like hot cakes to the auto industry at the start of the 20th century, and to aircraft manufacturers a little later. ©

## SMART DUST

**Oh no:**

During a test at the University of California at San Diego, Jamie Link dropped a highly delicate silicon chip. The extremely fragile object split into countless pieces.

**Aha:**

Link examined the tiny pieces and realized that they maintained their original characteristics as sensors. They continued to be capable of gathering and relaying data. The development became known as "smart dust."

**Effect:**

A single "smart grain of dust" can be less than a millimeter (0.04 inch) long. With suitable programming, numerous sensors can collectively gather helpful information, for example, in agriculture and medicine, such as identifying areas to fertilize or where a tumor is. Link's "smart dust" was a gamechanger. ©



## DEUREX PURE

**Oh no:**

The Deurex company produces industrial waxes. During a test in 2010, an employee let a machine run overnight with the wrong temperature and pressure settings. The next morning, the production facility was covered with ten tons of a cotton-like substance.

**Aha:**

The manufacturer did not discard the accidental product. Instead, in a test, the company discovered that the substance could bind with oil due to its fibrous structure and the resulting capillary action. The product is capable of absorbing seven times its own weight.

**Effect:**

This accidentally manufactured product is available today as "Deurex Pure." The binding agent soaks up leaked oil without leaving a trace. It is even reusable. Its features are in demand as a way to gain control of oil catastrophes. It also absorbs leaked lubricating oil from wind turbines. ©



## RIDING HIGH IN THE NORTH



In Norway, electric mobility has become a part of everyday life.

One new car in three has an electric powertrain on board.

Even if success has so far depended on government subsidies, the Scandinavian country is considered the world's most important test market for the technology. But the complete elimination of the internal combustion engine is not yet in sight.

The days are long right after “Midsommar,” the day of the solstice. In Oslo, people get together outside and have a beer with friends, enjoying the experience with a view of the fjord. The square in front of the “Iceberg,” the nickname for the opera house that opened in the former harbor district in 2008, has become an especially popular meeting spot. Here we meet Magne Bjella, who markets the opera on social media and online. In his mid-fifties, he feels like a pioneer in an industry that, along with classic advertising, largely relies on good critical reviews in the newspapers to shape opinions. “We have to

keep moving in new directions,” said Bjella, who took the job just a couple of years ago. So it's hardly surprising that he drives an electric car. “But it was more or less an accident that I made the switch,” Bjella admitted. When he went to his dealer, he only wanted a replacement for his aging car. But he had the chance to test-drive an e-Golf — and then decided on the electric model despite his reservations about its range. “Everything is like a normal Golf, only a bit better,” he said, summing up his experience after two years of everyday use.

Bjella's decision no longer makes him an anomaly. In no other country has electric mobility become so commonplace. Registrations of battery-powered electric vehicles have risen to 150,000, which exceeds the total number for Germany, despite the fact that Norway only has slightly more than 5 million inhabitants. The market share for electric vehicles was 18 percent during the first half of 2016. That roughly corresponds to the level of the previous year, highlighting the fact that the internal combustion engine has still not been decommissioned in the country that has become the model

for electric-vehicle fans. Over the last three years, the market share for plug-in hybrid vehicles has especially grown. It has now reached 16 percent.

One new car in three drives purely electrically at least occasionally, a share high enough to seem unbelievable. In China, 8 percent is considered initially adequate; a quota decreed by the government is being developed there. And in Germany, the share recently stood at just 1.3 percent despite incentives. That was still double the figure for the previous year.

#### CHARGING, NOT FUELING

In Oslo, the charging stations for electric cars in the city-center are already part of everyday business life.



Governmental support is the most important reason for the success in the North. Buyers of electric cars aren't just spared the value-added tax of 25 percent; they also avoid the "purchase tax," an additional acquisition tax comparable to the German land transfer tax. In all, these governmental waivers often make it cheaper for the customer to buy an electric car than a model with an internal combustion engine. In June 2017, the special provisions were extended to the year 2020. The consensus cuts across party lines, although there were voices earlier in the Labor Party proposing limits on the incentives for vehicles with a net price of 500,000 kroner, the equivalent of 53,000 euros.

#### ELECTRIC CARS PARK FOR FREE

Norway hasn't wanted to put its trust solely in lower purchase costs as incentives for electric vehicles. Other measures have been in effect for years: Electric cars so far have been allowed to park free of charge in city centers. Drivers have not had to pay fees for the many bridges and ferries along the country's craggy coast and are even allowed to use bus lanes during morning traffic jams. While these provisions have been decreed centrally to this point, it is now up to the municipalities to decide what benefits they will grant drivers of electric cars. That's because electric mobility has become a significant cost factor for communities. There are estimates that Oslo alone loses 35 million euros in income every year by foregoing road use fees.

#### HIGH RANGE, HIGH DEMAND

In light of the otherwise favorable conditions, the modest range of electric vehicles so far should be seen as the primary reason that two-thirds of drivers still choose a vehicle with an internal combustion engine. Norway is a thinly populated country, and a trip from Kristiansand in the South to Nordkap covers more than 2,000 km (1,250 miles). Even if most southern Norwegians never drive that far, many city dwellers have houses in the mountains or on the coast. "Fifty percent of all distances that are traveled in Norway cannot be completed with current electric cars," says Christina Bu, General Secretary of the Norwegian Electric Car Association and a passionate advocate for electric powertrains. "To address this market, we need larger electric cars with longer ranges at reasonable costs." The Opel E-Ampera, which has an electric range of 520 km (320 miles) in the New European Driving Cycle, shows that a better product could continue to increase demand. More than 4,000 orders have piled up for it in Norway, pushing the delivery times to more than a year. The car is manufactured in short production runs.

Ulf Tore Hekneby is also thrilled with the demand for electric cars. He is the Managing Director at Møller, the Volkswagen importer. He has four months' worth of preorders for the new e-Golf, whose range has been improved to 300 km. "The entire market is revolving around the issue of range," Hekneby said. About half of all the Volkswagens sold in Norway have either an electric battery system or a plug-in hybrid powertrain. It is no accident that the brand has a significantly higher share of electric vehicles than its competition. With the introduction of the e-Up four years ago, the importer decided to align the entire dealer organization with the new powertrain. Unlike the situation in Germany, it was not just individual specialized dealerships that were trained in sales and service – it was each of its more than 60 retail operations. "That's how we paved the way for the future," Hekneby said.

#### ALREADY EMISSION-FREE IN 2025

If things continue the way Norwegian policymakers would like, only emission-free cars will be registered starting in 2025. "The goal has been adopted by the Norwegian Parliament," said Bu. But she points out that Norway can't go alone. It is not a member of the European Union, but it is in fact part of the European Economic Area (EEA). "We have to adhere to its rules," Bu said. The country, which owes its wealth to its petroleum and natural gas reserves, is also experimenting with alternatives to battery-powered mobility. In July, a consortium led by Nordic Blue Crude announced the production of a crude oil substitute on the south coast beginning in 2020. Water and carbon dioxide serve as its raw materials with the help of a reaction aided by green electric energy from hydropower. The carbon dioxide is due to be obtained in part from ambient air using a process developed in Switzerland and would be completely climate-neutral. The annual production of 10 million liters (2,640,000 gallons) a year would be enough to run 13,000 cars with synthetic fuel. If this oil substitute produced for the first time on an industrial scale proves itself, Norway could become a model for emission-free long-distance and freight mobility as well. ©

# FACTS AND FIGURES ON ELECTRIC MOBILITY

## MARKET SHARES FOR ELECTRIC AND HYBRID VEHICLES TODAY

New car registrations 2016

Electric and hybrid powertrains

Internal combustion engines



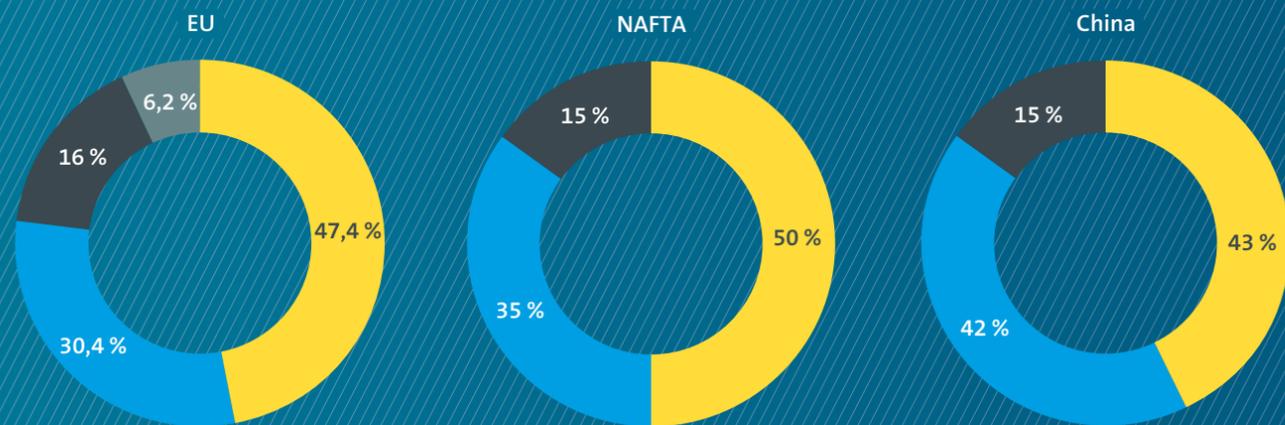
## POWERTRAIN MIX IN 2030

Hybrid powertrains

Electric powertrains

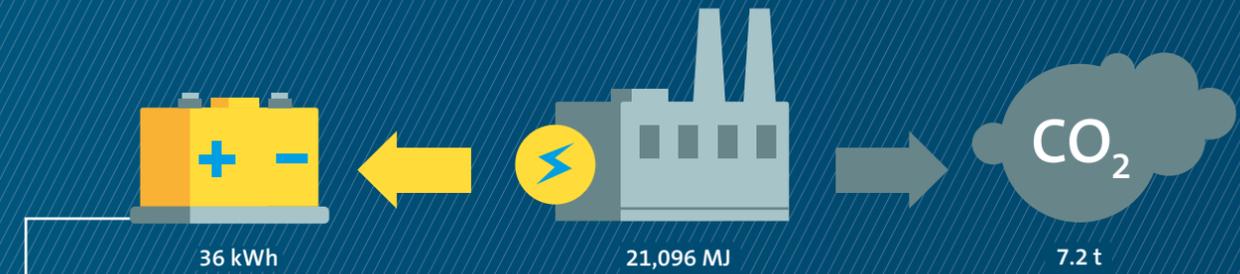
Internal combustion engines

Other



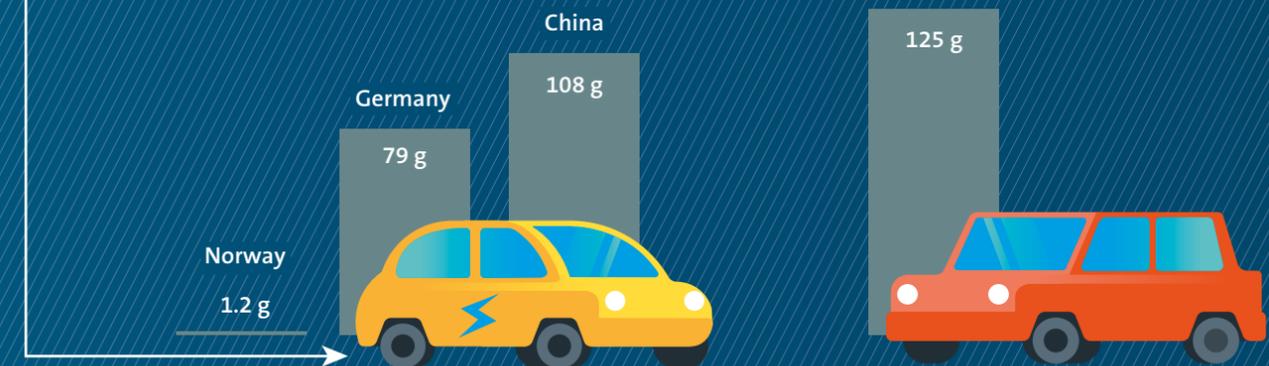
## CO<sub>2</sub>-EMISSIONS FROM BATTERY PRODUCTION

21,096 MJ of electrical energy are required to manufacture a battery for an average electric car with a charging capacity of 36 kWh. In the current electric power mix, that corresponds to CO<sub>2</sub> emissions of about 7.2 tons.



## CO<sub>2</sub>-EMISSIONS DURING DRIVING

CO<sub>2</sub>-emissions from an electric car per kilometer



Electric car with an electric power consumption of 15 kWh

The CO<sub>2</sub> emissions for electric cars vary because of the different power generation mixes of the individual countries.

Current diesel vehicle

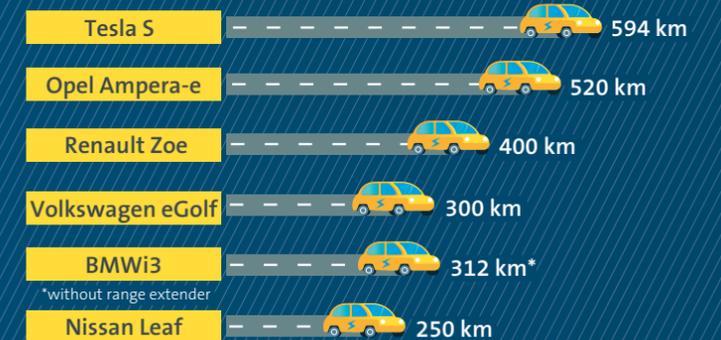
In every country, a diesel vehicle emits the same quantity of CO<sub>2</sub>.

## TOTAL NUMBER OF PUBLIC CHARGING STATIONS IN GERMANY



\*2017 includes privately operated parking structures/parking spaces for the first time.

## RANGE OF POPULAR ELECTRIC CARS





## LINE ZERO

By 2022, Wiesbaden plans to do away with all its diesel buses and replace them with electric models.

That would turn the spa town into Germany's pioneering city for local, emission-free public transport.

But the conversion can only take place if ESWE's overall plan becomes a reality.

On workdays, a traffic jam regularly forms in the bus lane in front of Wiesbaden's main train station, a showpiece of the German art nouveau movement. The transit buses drive up every few seconds in a discontinuous round dance, disgorging and loading passengers. The number of passengers will reach 56 million in 2017, the highest figure ever. On this scale, the boom in local public transit in the Hessian capital has nothing to do with the threat of driving bans. Residents of some main streets are demanding them due to increased nitrogen oxide levels. Instead, it has to do with the systematic expansion of the services and reliable operation. "If you are a user and you know that the bus is certain to come, then you are much more inclined to do the transfer," said Frank Gäfgen, Managing Director of operator ESWE.

The strategy, in effect for three years, has proven itself. But Gäfgen no more intends to lie back than Hermann Zemlin does. A colleague on the Management Board, Zemlin is a pioneer of German local transit and still wants to set priorities at the age of 76. Together, the two want to turn Wiesbaden into Germany's model for emission-free local transit. The vision is due to materialize in 2022, an objective that is more ambitious than that of any other city in Germany, Berlin included.

A bundle of measures is already on the way to keep the plans from gathering dust on the drawing board. This includes reconstructing a streetcar line on the most heavily traveled route, which connects Wiesbaden with Mainz on the opposite side of the Rhine. Like other medium-sized German metropolises,

Wiesbaden did not rebuild its decimated streetcar network after World War II — it replaced it with buses. But the transport capacity of a streetcar is more than three times that of an articulated bus — and it produces no exhaust-gas emissions. When there is a connection between the main train stations of the two cities, rail transportation will not just replace 30 public buses, it will be able to transport 22,000 more people — the mathematical equivalent of 16,000 cars per day.

Electric buses are due to replace diesel-powered buses on all the other lines. In the next five years, 221 vehicles — a substantial number — are expected to be purchased to meet the city's needs. But it's not that easy to draw up the request for proposals, Gäfgen said. "Battery technology continues to advance, and prices



are falling. We naturally want to take part in this and always take advantage of the latest developments." That wouldn't be a problem if individual vehicles are bought in small batches. "But we want an overall system," Gäfgen said. "The vehicles have to match the charging infrastructure as well as our operating processes." That's why he is betting on a close collaboration with a single vehicle manufacturer. His philosophy is that the conversion should seem absolutely seamless to passengers — no breakdowns and no loss of comfort.

ESWE is already working on the process to supply the 221 buses with electricity. The efforts include a precise analysis to determine the energy needs of the buses on the current routes. They also involve cooperation with its sister company, the municipal electric utility, on a system for charging the vehicles. "We have a major advantage in that the energy needs for public transportation can be forecast very precisely," Zemlin said. As a result, it should be possible to buy green energy at attractive terms.

ESWE expects the range of the electric buses available in 2022 to be between 250 and 300 km (155 to 185 miles), and they will be able to meet more than 90 percent of its current transportation commitments. Fuel cell technology could be an attractive option for the remainder, which have relatively long daily routes. It is now being tested as part of a pilot project. Fuel cell buses also operate electrically, but they draw their energy from a hydrogen tank, not a battery. "We expect hybrid vehicles to catch on — they have a combination of battery-electric and fuel-cell powertrains on board," Gäfgen said.

There is also recognition in other German cities that the public sector has responsibilities on the zero-emissions issue. For example, the mayors of Hamburg and Berlin have teamed up to buy emission-free transit buses. Together, the cities are expected to buy at least 200 zero-emission buses per year starting in 2020. Pilot tests converting individual bus lines to electric powertrains are already underway in both cities.

Hamburg is especially proud of its "mountain goat" — a midibus line that circulates in the city's genteel, hilly Blankenese district. According to VHH Managing Director Thoralf Mueller, the electric buses have pulled even with their diesel predecessors in terms of costs and their availability — more than 90 percent. And, like his colleagues in Wiesbaden, he is hoping that bus manufacturers quickly expand their product lines. If the trend continues, the market is likely to be attractive enough: According to the Committee of the Regions, there are about 200,000 transit buses in use in the European Union. ©



## DELIVERING MAIL ELECTRICALLY

Deutsche Post DHL had been looking for the right electric van for a long time – it wanted to make local deliveries CO<sub>2</sub>-free. Then it took action on its own. It acquired a startup and began building its own vehicles. Now the purely electric “StreetScooter” is enjoying a veritable boom. A third model line is under development, and a second production facility is due to be built in North Rhine-Westphalia.



Hamburg, Landungsbrücken. A small yellow van owned by Deutsche Post is parked in a no-stopping-zone at the Baumwall bus stop. With its cute, almost square design, it looks as though it could have come directly from the Miniatur Wunderland in the Hafencity across the way, except for its somewhat larger size. A handful of passersby gathered around the vehicle, pulled out their smartphones and took pictures – but not because of the apparent violation that the mail carrier – who was absent for just a short time – had committed. The reason was the special message inscribed in green letters on the cargo area. “An electric powertrain propels this vehicle.” Upon closer inspection, there is something even more remarkable: The badge displayed at the center of the hood is not the logo of a well-known vehicle manufacturer but rather the emblem of Deutsche Post. It is as though the curved-horn insignia wanted to noisily announce to the world: “We’ve become a vehicle producer.”

### ELECTRIC SCOOTER AS FORERUNNER

The paradigm shift to electrified mobility has become a reality for Deutsche Post. It all started in Shanghai in 2006. When a German engineer stepped out of the airport terminal, he was nearly run over by a passing electric scooter. Achim Kampker, then the head of a medium-sized auto supplier, was not expecting the silent hazard and nearly collided with the two-wheeler. In hindsight, he is surprised at how quickly electric mobility can take hold with the right framework in place. For example, electric mopeds have caught on quickly in China’s inner cities because lawmakers have banned two-stroke combustion engines from the country’s metropolises. Three years later, Kampker joined his doctoral advisor Günther Schuh on a research project. “We wanted to find out what methods would make it possible to develop an electric vehicle in a very short time and at a very low cost,” Kampker said, looking back. That very same year, he resigned his old job and became a professor at RWTH Aachen.

This renowned technical university was the nucleus of a project that was quickly picking up speed. It initially involved a consortium consisting of StreetScooter GmbH, RWTH, other research institutes and about 80 medium-sized companies. It presented an early prototype at IAA 2011 – then still in the form of an electric passenger car. Then StreetScooter caught

the attention of Deutsche Post DHL, and it teamed up with Kampker to further develop the vehicle for letter and package deliveries. The first 50 vehicles were built back in 2013. This fast pace of development is typical for startups, which forego long investment processes and just get rolling. But Kampker also considers this to be a philosophy. “We need too many resources, and the time is short,” he said. “To create a sustainable world, we have to increase the speed of innovation – and implement the innovations in the end as well.” During the winter of 2014, Deutsche Post DHL acquired the startup and integrated it into the company as a subsidiary. Kampker became the division manager for electric mobility.

“We wanted to find out what methods would make it possible to develop an electric vehicle in a very short time and at a very low cost.”

Achim Kampker

The electric StreetScooter has meanwhile enjoyed an outright boom. More than 3,000 electric vans built at the StreetScooter plant at the Aachen site are being used to deliver mail across the country. Working with mail carriers in the Bonn area, engineers first tested an early model line with four cubic meters of cargo space for the joint deliveries of letters and packages. But that version proved to be too small for just package deliveries. That’s why StreetScooter added a second model line with eight cubic meters of cargo volume. It is initially replacing diesel vehicles in the Bochum inner city and subsequently in several other major German cities, ranging from Hamburg to Munich. A third, even larger model line is now in the planning stages: In a joint project with Ford, vehicles with twenty cubic meters of cargo volume are scheduled to be in production by the end of 2018, using the Ford Transit chassis. Total production capacity is being expanded to 20,000 vehicles annually, and a second factory in North-Rhine Westphalia is planned. The long-term goal is not just to replace Deutsche Post DHL’s entire delivery fleet – at least 47,000 vehicles – with electric scooters. The three model lines are also due to be sold to other logistics companies.

## E-COMMERCE AND E-TRANSPORT

This success has even piqued the curiosity of established automakers. In August, it became known that a major German OEM rented a StreetScooter through an intermediary. The car was not driven through the region during the rental period as expected – instead, it mainly stayed on the grounds of a plant owned by the interested manufacturer in southern Germany.

The demand for Deutsche Post's electric van is not surprising at all, given the still-rising Internet trade and the simultaneous threat of bans on conventional delivery vehicles. "With the StreetScooter, we can show that the delivery of more packages due to the e-commerce boom is not tied to growing CO<sub>2</sub> levels," Kampker said. "On the contrary, we can even reduce our emissions." The use of electric vehicles even makes sense operationally since it can get around the proposed bans to block diesels from entering many cities, he said.

Deutsche Post's development efforts have another advantage, Kampker said. "We have involved our delivery staff in the vehicle's development to create the best possible electric vehicle for delivery transportation," he said. This is especially important for the door openings, which provided especially good ergonomics with their robust hinges and a recess for the driver's foot. The reason: During a typical day, a mail carrier has to leave and re-enter his vehicle up to 200 times. That's why the door designers examined the various postures and movement sequences that the mail carriers in the test exhibited while entering and



2006

Start of project



2013

50  
manufactured vehicles



2017

3.000  
vehicles in use



PLANNED

47.000  
vehicles in the entire fleet

exiting. The doors to the cargo space are also important: They not only need to be the right size – in each situation, they have to allow easy and fast access to the shipments being delivered. That's why loading and unloading can take place from the right or the left, as well as from the rear. This means carriers do not have to crawl inside the vehicle as part of their daily routine. In addition, the backup camera is supplemented by a second camera at the right rear side because the view from the driver's seat is particularly limited in that direction during maneuvering.

The StreetScooter at the Hamburg bus stop was starting to maneuver as well – the mail carrier had meanwhile appeared, at just at the right time. From behind, a Line 111 bus was approaching on its way to Hamburg-Altona, and its driver was expressing his displeasure with his headlight flashers. A short sprint with a soft purring noise, and the mail vehicle was back on its rounds. An electric powertrain can't help you here: Even a vehicle propelled by electricity needs a place to park. ©



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## HOUSING SEAL FOR SMALLER VOLUMES

**With a new, original seal for traction-battery housings, Freudenberg Sealing Technologies is helping to make electric vehicles more economical to produce in smaller volumes. The patented "Profile to Gasket," or P2G, concept was developed for volumes of up to 5,000 batteries per year.**

For profiled flat seals, the cross-section and dimensions are adapted precisely to a particular battery. For very low volumes, seal profiles come into use – their length can be manually trimmed. What has been missing so far: a solution for the medium volumes that now dominate the electric vehicle market. P2G closes this gap. This housing seal handles sealing and attachment in separate areas of the seal profile. A compressible hollow profile on the exterior of the seal – which is up to 15 mm (0.6 inch) wide – prevents the penetration of liquids and particles into the housing. The seal can be attached to the housing with a fixation strip on the inner side. The P2G seal can be produced as an endless band and then trimmed to the length needed in each case. With targeted incisions in the attachment area, it is possible to guide the seal in tight radii around corners. Concave and convex radii can be achieved. Even very large battery housings can be reliably sealed with this endless profile. Vehicle and battery manufacturers can decide whether to obtain the P2G seal as an endless product or as individual seals that are already trimmed and equipped with a clasp. ©



## TURNING TWO INTO ONE

**The traction batteries of electric vehicles are protected by a metal housing. It has a pressure compensation valve to allow it to react to fluctuations in air pressure and temperature. A second valve enables the rapid escape of gases in the event of a battery malfunction. Freudenberg Sealing Technologies has developed a smart pressure compensation element, called DIAvent, that combines both functions in a single component.**

As the component was developed, engineers had to consider the fact that merely small amounts of air per minute were exchanged bi-directionally under the usual pressure compensation conditions. In an emergency, however, the amount of gas emitted from a damaged cell must be completely drained away in a few seconds. The solution, for which a patent has been filed, consists of a combination of two nonwoven materials with different characteristics. With their interplay, they guarantee that an air exchange of about eight liters per minute occurs at a slight pressure difference. Nonetheless, no water penetrates the housing. An umbrella valve, arranged in the shape of a ring around the nonwoven material, permits degassing in an emergency. It opens up as soon as the pressure in the housing exceeds the atmospheric pressure by more than 50 millibar and can then drain off 40 liters (10.5 gallons) of gas per second. Unlike prior solutions, the umbrella valve closes up again afterwards. Since it opens up fully reversibly, it can support pressure compensation in normal operation. ©



## AN ADDITION TO THE FAMILY



The English diaphragm specialist Metflex has been part of Freudenberg Sealing Technologies since mid-2017. The medium-sized company not only offers materials with unique quality but it also has a strong position in the natural gas market.



TECHNOLOGY EXPERT

Steven Parry is in charge of material development at the Blackburn (UK)-based company.

People know all about robust materials here, in the northern reaches of the Manchester and Liverpool industrial region. Once it was bricks from Accrington that earned a worldwide reputation. For example, the foundation of the Empire State Building is composed of the high-strength clay mined here. Today it is unique materials used in the natural gas industry. At first glance, the material that Steve Parry is holding seems anything but tough. But the fiber-reinforced diaphragm is five times as durable as any conventional elastomer. It is used in gas meters, where it continually stretches and retracts, in line with the amount of gas consumed, over a period of 20 years. Neither fluctuating ambient temperatures nor material aging can be permitted to disturb the precision of its deflection. That measurement – which determines what the consumer pays for his gas supply – is only as accurate as the diaphragm permits. In this application, an expansion of the diaphragm of just 200 µm can determine success or failure.

ENVIRONMENTALLY FRIENDLY ENERGY CARRIER

Parry, who is in charge of material development in Blackburn-based Metflex, won't reveal the secret behind "Dispersed Fibre Technology" (DFT). At its core, it involves strengthening the flexible elastomer diaphragm in specific targeted zones by

introducing certain particles. This occurs when the base material – already mixed with fibers – is injected into the tool. How the material flows into the mold determines where the fibers accumulate. The production process can even establish their orientation in certain directions. This is important because the strength of the material across the fibers is much greater than in the longitudinal direction of the reinforcement. The material and its associated production technology were developed around the turn-of-the-millennium. There was no software that could have been used to simulate the process in advance. After countless series of tests, the DFT diaphragm began to be used in a pressure regulating unit in gas pipelines in 2003. Its use in gas meters followed a short time later; Metflex in particular was able to conquer the U.S. market with it, said Chris Greenwood, Manager, Sales and Marketing. The timing was good because the country had just reached the peak of a natural gas boom. Unleashed by domestic production, this environmentally-friendly energy source – whose CO<sub>2</sub> emissions during combustion are 50 percent less than those of coal – gained substantial market share.

Metflex has been part of Freudenberg Sealing Technologies since mid-2017. Its former private investors sold the company. Dr. Dieter Thiel, Director of the Global Lead Center Diaphragms at Freudenberg Sealing Technologies, believes his British colleagues represent a great opportunity. "Metflex has technological expertise and market know-how in the gas market that

we have lacked until now." With 90 employees, Metflex is a typical medium-size company: It has indeed invested in new technologies in the past, but now more opportunities will be emerging with the companies combined. For example, in China and India, where natural gas is gaining importance as a source of energy. "But at the moment, we are mainly busy bringing Metflex into the Freudenberg family," Dr. Thiel said.

BROAD PRODUCT DIVERSITY

Process control and the precise design of the production tools play a role in the use of the technology. They require experienced employees like Phil Rycroft, who is in charge of production at Blackburn. He proudly guided his visitors through the hall where about 40 million diaphragms have been manufactured with the DFT technology. But even though gas diaphragms are the company's main business, a broad range of other products is emerging here. It includes tiny components as well as diaphragms with a diameter of up to two meters. The array of applications is correspondingly broad. High-end speakers for concerts are one example. "At many rock concerts, our products are on stage with the stars," Rycroft said proudly. The portfolio also includes connection elements for underwater pipelines, special seals used in aviation and dampers for energy facilities on land and the high seas – that is, products whose defect-free operation is crucial. So Rycroft does all he can to guarantee zero-defect production. This means monitoring all the individual process steps. The material is either mixed by the company on site or subjected to an incoming inspection in the lab. The process know-how not only involves vulcanization in presses – which run from 50 to 500 tons – but also the surface pretreatment of metallic materials for composite components. Metflex has also developed a process in which a fabric is furnished with an elastomer layer on both sides and then trimmed. The equipment is much like one of today's printing presses – it's fully automated. The Metflex engineers have developed unusual approaches again and again. For example, it is a special challenge to manufacture a burr-free component during the injection molding of elastomers. The de-burring is difficult, especially on very small components. Here Metflex has developed a special process that leaves the parts relatively free of burrs. Clever ideas of this kind have allowed a relatively small company to make its way successfully in the global market.

For several years, Metflex has had some of its products manufactured by a contract manufacturer in Malaysia. "That creates a high level of security for our customers who often order 100 percent of a product from us," Purchasing Manager David Hudson said. "This also gives us access to growth markets in Southeast Asia." The principle of continual quality control

applies here as well. It is not only material procurement that is monitored from Blackburn – the components produced abroad regularly undergo exhaustive tests in the company's labs.

Blackburn is proud of the "Metflex" brand and its success in the oil and gas market. Ralf Schmid, Manager of the Special Sealing Division, is confident about Metflex's and FST's prospects. "The company is a good fit for us based on its product portfolio, technologies, development and marketing expertise, and its strong value orientation." That's not surprising at all, given the history of Metflex. When it was founded in 1919, the company was called the "Metropolitan Leather Company." The main products were flat and ring seals made of leather. But Freudenberg's management does not intend to focus on the past but rather on the companies' common future. "We are well on our way as far as integration goes," Schmid said. ©

MANUAL WORK

The challenge in the injection molding of elastomers lies in producing the component burr-free.





## NOT A SECONDARY ISSUE

Electric propulsion is quite straightforward when it comes to trains – but only if a contact wire is available. Three highly committed individuals at DB RegioNetz are working on an alternative to reduce the consumption of diesel fuel on partly or completely non-electrified secondary routes. A hybrid technology that has already been tried-and-tested on the road is now expected to make its way into rail transportation. The goal is to obtain the approval for an EcoTrain next year and to start converting the first vehicles in 2019.

From Frankfurt to Paris, purely electrically, without a break for charging, in less than four hours. What sounds like a utopia for electric cars is already a reality for trains. If you are traveling by train, you are traveling under electric power – that is the generally accepted view. But at a number of provincial train stations, when incoming diesel locomotives spew their clouds of soot, things seem very different. While nearly 100 percent of Switzerland's rail network is electrified, the figure is only a bit more than 50 percent for France and roughly 60 percent for Germany. And not every secondary route is suitable for retrofitting with contact wires. That's why DB RegioNetz Verkehrs GmbH, a subsidiary of Deutsche Bahn, is launching an innovative project that is expected to take a technology –

smart hybrid vehicles – from the roads to the rails. Here the vehicles are not just equipped with a diesel engine but with electric motors and a battery as well.

At the railway company, this environmentally-friendly, hybrid-powered locomotive is known as the EcoTrain. It started out with an early test and demonstration vehicle on the Ore Mountains Railway route, which has four legs up into the mountains from Chemnitz and Zwickau. At 600 meters (2,000 feet) above sea level, it reaches Annaberg-Buchholz and the highest point, 912 meters (3,000 feet), at Johanngeorgenstadt, so it can then move down the steep descent as far as Karlsbad – on the Czech side on weekends. “The Ore

Mountains Railway has one of the most demanding routes in all of Germany,” said Sören Claus of RegioNetz, who developed the project jointly with his colleague Claus Werner and their team. “If it works here, it will work anywhere.” In July, the two were put in charge of RegioNetz's new Vehicle and Technology Center (FTZ), with Claus Werner as the spokesman and Sören Claus as the commercial manager. Here they will team up with the technical manager Mike Juntke to build the first pre-series EcoTrain vehicle. The plan is being sponsored by the German Federal Ministry for Transportation and Digital Infrastructure (BMVI) as part of the “Model Regions Electric Mobility” project” which is being coordinated by the National Organization Hydrogen and Fuel Cell Technology.

“During the conceptualization, we gained a great deal of experience on how this kind of project can be carried out,” Claus Werner said. “At FTZ, we will now convert stock vehicles as a single supplier, from the first idea to the design, all the way to manufacturing.” A short production run of twelve vehicles is already being planned.

Diesel-mechanical locomotives from the Siemens Desiro 642 model line, a widely used local-transit multiple unit, are the basis for the EcoTrain. DB Regio alone has 234 vehicles of this type in use, and there are more than 600 vehicles from this model line active Europe-wide. “First, the vehicles are completely gutted and one of the two diesel engines including transmission is then replaced with our energy-efficient module consisting of electric motors, power electronics and a battery,” Juntke said. “The propulsion will then be purely electric with two 300 kW electric motors, fed by a 153 kWh lithium-ion battery.” If that is not sufficient, then the remaining diesel engine kicks in, producing electric current for the electric motors. Based on the hybrid experts' calculations, this reduces diesel use by about 50 percent. In addition, the sooty black smoke will be gone from train stations, and the noise level will fall sharply.

The EcoTrain exploits one of its most important strengths whenever its route runs downhill. The electric motors then function as generators, recapturing braking energy and storing it in the battery storage device. An energy management system determines exactly how the diesel engines and the electric motors work together; it was developed by the Regio networks team in cooperation with TU Dresden, TU Chemnitz and the Fraunhofer Institute IVI. “For one thing, we always operate the diesel engine within an operating range with the lowest possible fuel consumption,” Sören Claus said. “For another, our energy management system is supported by a route planning assistance system,



OUT OF CONVICTION  
Sören Claus and Claus Werner direct the innovative project at DB RegioNetz Verkehrs GmbH.

known as FASSI, that we developed ourselves.” FASSI knows the route in the Ore Mountains in precise detail. Every rise, every curve and every train station. For example, it can calculate whether the locomotive's battery charge is sufficient to complete the trip, and, should the opportunity arise, whether to shut down the diesel engine. The system can also reduce the output of energy-consuming auxiliary units such as air-conditioning to increase the train's range. “Depending on the operating conditions, we can reduce CO<sub>2</sub> emissions by up to 35 percent,” Sören Claus calculated.

To exploit other potential, the three colleagues are already thinking a step ahead. So far, they envision recharging with a plug and cable. But there are already plans for a current collector on the EcoTrain's roof. “That way, we can recharge the battery more quickly and conveniently at the terminus,” Claus Werner said. Smart recharging islands are also conceivable at in-between locations. A small portion of the route is

being equipped with contact lines so that the EcoTrain can extend its electric current collector and take on energy during the trip. “At a more advanced stage, the remaining diesel engine could even be replaced by a second, hybrid-energy module,” Claus Werner said. The EcoTrain could then be driven completely electrically – with current that is generated renewably.

The Regio networks are developing an approach based on this exact idea for the Southeast Bavaria Railway (SOP). On the Munich-Mühldorf route, diesel locomotives pull double-stack railcars, even though the route to Markt Schwaben – about one-third of the entire stretch – has a contact line available. So the wire can be used, the three coworkers want to build the prototype for an “eco-diesel-electric multi-engine train” (Eco DeMe Train). It allows a power-supply railcar, which is attached to a conventional diesel locomotive, to be equipped with a current collector. If a contact wire is available, the current collector is extended. The trailing railcar then directly provides the electric motor with current, and the diesel engine can then be shut down. “This makes it possible to reduce CO<sub>2</sub> emissions up to 50 percent under the contact line,” said Claus Werner. The trailing railcar can also be equipped with batteries so the diesel engine will no longer be needed continually on the stretches without contact lines.

Since the requirements and the realities on particular routes vary greatly, the Regio networks' hybrid approach is deliberately designed to be modular. “That will allow us to retrofit existing vehicles very efficiently in the new Vehicle and Technology Center, and take the local infrastructure into consideration as much as possible,” Claus Werner said. He and his two comrades want to improve the sustainability of rail traffic on secondary routes. Hybrid vehicles can thus help society master the energy transition in transportation on the rails as well as on the roads. ©




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# A NATION BETS ON AUTONOMOUS DRIVING

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Singapore could become the first country in the world where self-piloted cars are an everyday reality. In this Southeast Asian city-state, the pressure for new forms of mobility has been combined with political will. And Singapore has had experience with radical self-renewal.

Climb in. Close the doors. The car starts up. The steering wheel turns as if by magic, and the passengers in the backseat don't quite know whether they should look out the window of the taxi or watch the eerie steering wheel do its work. So autonomous driving is the future? It's already the present in Singapore. "It is truly comfortable. And exciting!" said Lisa Low in an advertising video for the American firm nuTonomy, which specializes in programming software for self-driving vehicles. A camera filming inside the taxi reveals an unmistakable tenseness in all the occupants. People are just not used to completely consigning their fate to an automated car.

But above all, it is a market that many companies think is worth billions. nuTonomy even puts the potential for "Mobility on Demand" at \$3 trillion worldwide by 2030. According to the calculation, people won't own a car anymore. They will call for one – or type with a finger on an app. The second part of the calculation: The labor costs for taxis now account for 50 to 70

percent of their total expense. So if you let your taxis drive autonomously, you would be superbly positioned in the on-demand market.

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## TESTS TAKING PLACE WORLDWIDE

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It is no wonder that a wide variety of companies are in the starting blocks. The ride-brokering service Uber is testing a vehicle fleet in Pittsburgh in the United States, and the Google sibling Waymo has announced a program for selected families in Phoenix, Arizona. And in early 2017, the Swedish automaker Volvo disclosed similar plans for Göteborg. More than 30 companies have already committed to the vision of driverless cars. German automakers and suppliers now lead the list of global patent filings in this area. At present, America and Europe are the usual regions where you would expect innovative ideas. But how does Singapore fit into this?



In fact, the Southeast Asian city-state could be the first country in the world that officially allows autonomous driving on its roads. Despite the numerous trials, this is still not the case anywhere in the world. Even the test drives for the project involving nuTonomy and the Singaporean taxi provider Grab still have the distinct character of a testing program. They are limited to the start-up and scientific quarter known as “One-North.” The cars being offered resemble bus lines with their clearly determined stops, and the benefit of reduced labor costs is still a bit distant: Two escorts sit in the car during the test drives – a driver who takes over manually if necessary and a researcher observing the operation.

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### ONLY 15 PERCENT OWN A CAR

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Similar limitations are in force at all the other test fleets worldwide, especially since crucial issues have still not been clarified: How do automated vehicles interact with their unpredictable, manually controlled counterparts – and how will the potential risks be legally regulated? They can be managed on private property and in industrial zones. Automated vehicles have long been gaining ground there. Automated forklifts drive through distribution centers, and the Rio Tinto mining company in Australia is using nearly 100 giant self-driving trucks with an empty weight of more than 400 tons to transport iron ore. But the everyday chaos of an entirely normal intersection pits robotic technology against entirely different challenges.

The fact that Singapore is progressing so energetically is anything but accidental. The city-state has a space problem. Even if Singaporeans are in the process of zealously reclaiming land from the surrounding sea, they will hardly end up with significantly more than its roughly 700 square kilometers (270 square miles) today. Nearly 6 million inhabitants already live in this space, and transportation routes have swallowed up about 12 percent of the surface, according to the Transport Ministry’s Land Transport Authority (LTA). Singapore wants to grow. “But we cannot build more roads – and we don’t want to,” a source from the ministry said. Anyone arriving in Singapore for the first time is often surprised at the generously laid out parks, green spaces and even forests, and the politicians

want them affected as little as possible. The people here are used to thinking far ahead, and that includes environmental issues. Cars in the city-state are subject to high taxes and fees, and the number of registrations is tightly restricted. Only about 15 percent of the population even have their own car. The rest rely on public transportation, buses, taxis and the Metro network. But here this highly industrialized country runs up against a skills shortage – it doesn’t have enough drivers and service technicians.

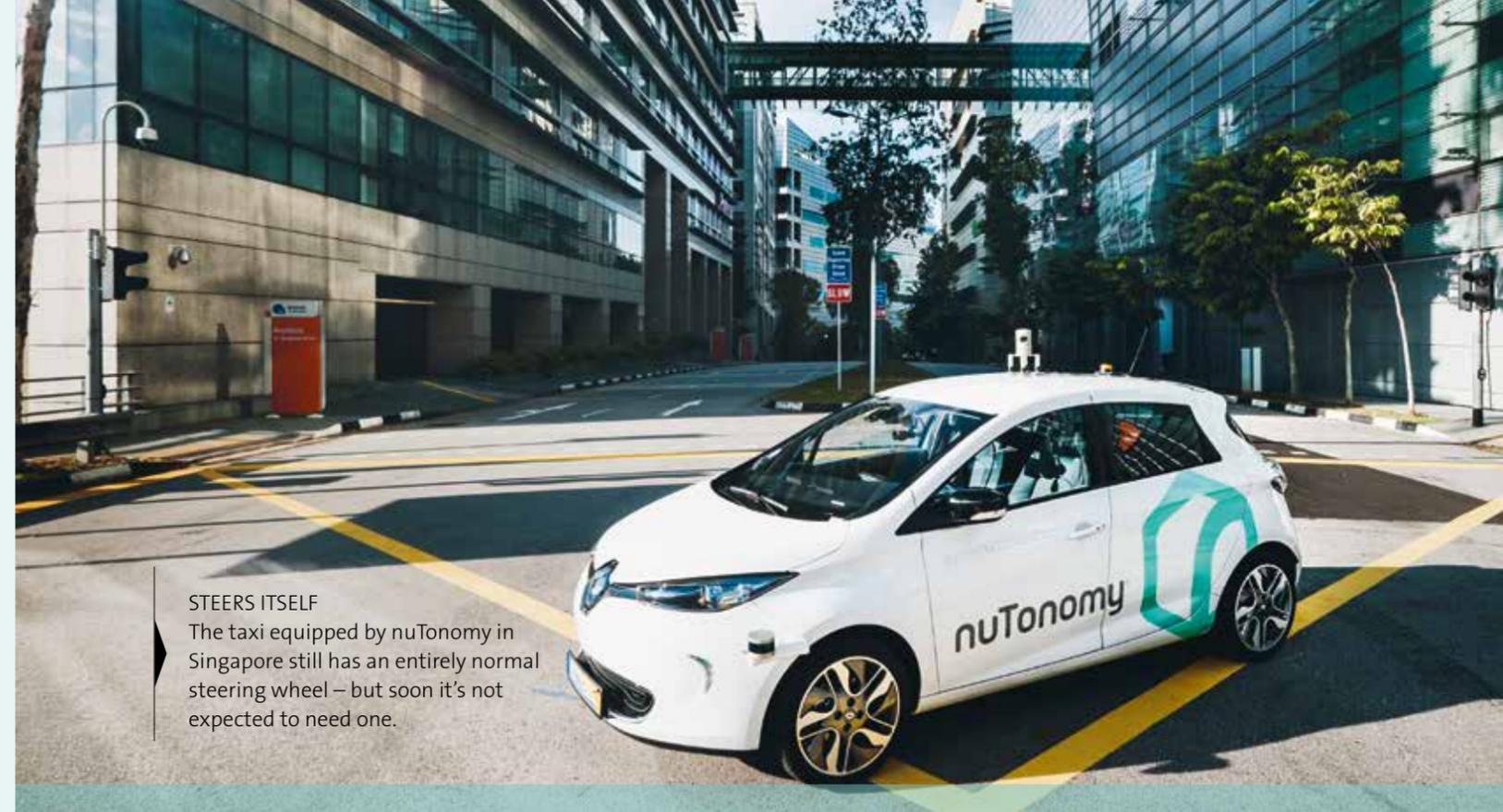
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### EFFICIENT, PRUDENT AND RUTHLESSLY DETERMINED

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Singapore also has an advantage in the competition for autonomous driving: a strong-willed political class – in a comparatively small space. When the country became independent in 1965, its politicians already faced a dilemma: no resources, no land, hardly any industry, not even well-disposed neighbors for trade. The groundbreaking decision that led to a very special departure involved a radical focus on education, services and globalization. The deal: economic freedom in exchange for political rights. The government that catapulted Singapore so successfully into the modern age and made it one of the world’s most economically successful countries was efficient, prudent and remarkably corruption-free on one hand. But it was de facto a one-party government: dominating, determined and ruthlessly subject to a vision of progress.

If you look at photos of Singapore from the 1970s, you will see potholes in the pavement, mold on the walls of homes, and laundry lines hanging over the streets. It looked like many cities in Southeast Asia’s newly industrialized countries: bustling yet a little rundown, not least of all due to the climatic conditions, including the heat and constant high humidity. Today, however, the city-state is a glaring contrast to its old image. The roads are in great shape, and the skyscrapers are iridescently modern. People often walk to the bus stop protected from rain under covered walkways. Taxis can already be ordered online. Anyone wishing to get a taste of the old, unspoiled Singapore has to seek it out – in hidden suburbs and on backstreets.



**STEERS ITSELF**  
The taxi equipped by nuTonomy in Singapore still has an entirely normal steering wheel – but soon it’s not expected to need one.

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### STANDARDS, RULES, PREPARATION: SINGAPORE MEANS BUSINESS

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A strongly authoritarian style of government offered a mixture of conditions for the creative spirit of entrepreneurial startups. Intelligence and education have indeed been venerated as values, creativity and deviating opinion less so. For example, some young, creative developers and entrepreneurs describe themselves as successful “despite my school education.” Singapore’s economy has become strong in biotechnology, electronics and banking services, but soberingly mediocre when it comes to patents and new business formation.

But when the government sees something as sensible innovation, it is supported energetically with clearly defined goals – as is the case with the testing of self-driving cars. For the city-state’s leaders, the autonomous taxi is the solution for short inner-city routes and the “last mile” to the Metro. A “Committee for Autonomous Transport for Singapore” (CARTS) set rules for the current tests. Besides nuTonomy, other companies and scientific groups have operations there. Bureaucratic hurdles have been loosened, incentives created. The local technical university NTU was given the job of developing standards for coding, networking and safety issues. The required digital street maps are currently being developed. The city-state is

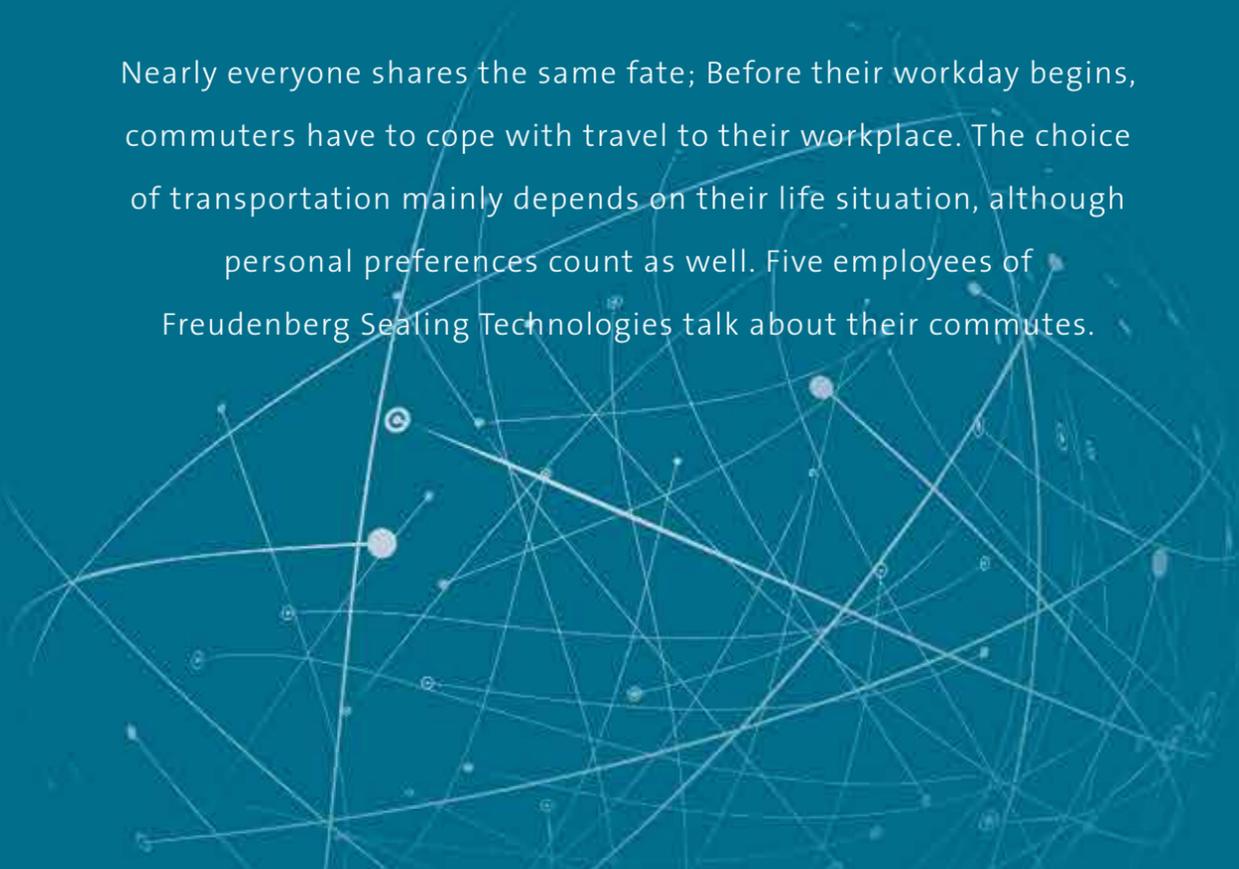
clearly ahead of Europe and America on all these issues. Since early 2017, an electric minibus has been traveling at up to 40 km/h (25 mph) to NTU. Singapore means business. And its more recent history shows that when the city-state’s government has a goal, it is ready to pursue it very systematically.

Prime Minister Lee Hsien Loong has already announced the next departure: Singapore wants to become a “smart nation.” Whatever can be networked in Singapore is to be networked. The Prime Minister’s message: “The world is changing. When we are not changing with it, we are falling behind.” The concrete plans of the latest initiative include equipping every streetlight with sensors and collecting data on everything from the weather to terror risks. Cash is being abolished, and car parking stubs are being replaced with an app across the board – in case someone actually needs a parking spot in the future and doesn’t just travel in a self-driving taxi. ©



# COMMUTER WORLDS

Nearly everyone shares the same fate; Before their workday begins, commuters have to cope with travel to their workplace. The choice of transportation mainly depends on their life situation, although personal preferences count as well. Five employees of Freudenberg Sealing Technologies talk about their commutes.



AVERAGE TIME OF COMMUTING



**James Klump**  
Detroit, USA

## THE MILE-MAKER

Every day for more than twenty years, fifty miles there and fifty miles back. James Klump is not sorry that he has a long commute. He and his wife – who is employed as well – have decided to live in a small town north of Detroit, the Motor City. “We feel at home there,” he says. Klump spends about two hours a day in his car. He tries to use this time as productively as possible, for example, by making calls to customers or listening to podcasts that he subscribes to. Comfort is the decisive factor in his choice of a vehicle. “On board, it has to be quiet enough that I can make phone calls without disruption.” A car built in the U.S. is the natural choice. A Sales Director, he handles Fiat-Chrysler as a client, and now drives a Dodge Durango. It is large enough to tow a trailer with a small all-terrain vehicle on board. Klump is thus well-equipped when he takes off with his brother on fall weekends and drives for seven-and-a-half hours on hunting trips to northern Michigan. ©



Source: American Association of State Highway and Transportation Officials: Commuting in America 2013. National Report on Commuting Patterns and Trends



**Luc Cron**  
Nantes, France

### THE ELECTRIC ENTHUSIAST

It was coincidence that led Luc Cron to buy an electric car. In 2013, Cron, a Quality Manager, and his wife found a Renault Zoe at a dealership in his hometown of Langres. At the time, the French government was incentivizing the car's purchase with a bonus of 7,000 euros, and Renault merely lent the battery to the consumer, which created price parity with a compact car. The cuddly French car has now been a part of Cron's family of five and their daily life for three years – and has proven its worth, at least as a second car. "We can ride in it comfortably for short trips." Cron is not bothered by its short range, about 110 km (68 miles). He still has his primary car, which has an internal combustion engine, in his garage for vacation travel. The Zoe is generally charged at home. "We have converted our house as much as possible to alternative energy," Cron said. "That's a good fit for the electric car." He also has a lot of fun driving it electrically. "We would not go back." ©



2.2 million inhabitants

580,000 inhabitants

MOBILITY IN FRANCE

NANTES

PARIS

47% on foot



**Manuel Gonzalez**  
Paris, France

### THE WALKER

Manuel Gonzalez tried it out. Like everyone else, he used to climb into his car in the morning and drive from the center of Paris to his workplace on the city's periphery. He struggled through traffic for three-quarters of an hour. It was even worse in the evening when he had to find a parking space in the 8th Arrondissement. He decided to do everything differently seven years ago. He started his commute with the suburban train and then walked for a half-hour to reach the office, rain or shine. "It keeps me fit," says the 60-year-old, who was active as a football player in his youth. The walking clears his mind. "I was often stressed out before, but now I have time to think things through." The first winter was hard, but Gonzalez knew one thing: "I can't quit." He sees benefits for the environment as well as for physical fitness. He calculates that he is keeping about one ton of CO<sub>2</sub> out of the atmosphere per year. ©

33% public transport

3% bicycle

17% car



**Winfried Heiser**  
Weinheim, Germany

### THE BIKER

Part of his job is health management. Mechanical engineer Winfried Heiser is responsible for health, safety and environmental protection Europe-wide for Freudenberg Sealing Technologies. So it is completely natural for him to set a good example. That's why he climbs onto his road bike two mornings a week and rides the 20 km (12 miles) to work in Weinheim. The trip would be significantly faster in his car, which he often uses for official trips, and he actually likes to drive. But the 53-year-old's time on the bicycle is a very efficient way for him to stay fit. "It is also more joint-friendly than jogging," Heiser said. When it comes to his bike, he doesn't rely on high technology – instead he uses a normal aluminum road bike, complete with fenders. He has nothing against e-bikes – they are certainly an alternative for less athletic people, he said. Since Heiser often has to wear a suit in his job, he frequently changes clothes on the factory grounds. It will all work out – if you want it to. ©

### COMMUTING IN GERMANY



50%

of the working population in metropolitan areas use cars to travel to work.



73%

in less dense rural areas use motorized individual transportation.



16.8%

of the employed population have a commute of more than 25 km (15 miles).

Source: German Federal Statistical Office: Geographic Mobility and Regional Differences. Data Report 2016

### THE METRO USER

Chen Qian has it good. There are only seven stops on Metro Line 4 between her home in Shanghai and her place of work. A 20-minute commute is an anomaly in this mega-metropolis with 23 million inhabitants. Like nearly all commuters in major Asian cities, she uses the time to chat or read the news on her smartphone. "This is very efficient," says the marketing specialist. She also praises the city's network. The first line was only opened in 1992, but its total length has now reached more than 500 km. "In general, you can reach all the city's key locations faster than with a car," Chen says. If she is going out, she takes a taxi in the evening occasionally. One of the Metro's peculiarities is that it shuts down at 10:30 p.m. until the next morning. ©



**Chen Qian**  
Shanghai, China

### THE LARGEST SUBWAY NETWORKS IN ASIA

Passengers per year



Source: Union Internationale des Transports Publics (Uitp.); World Metro Figures, October 2014

Source: European Platform on Mobility Management, <http://www.epomm.eu>



# HYPE – OR A GREAT FUTURE?

What now falls under the umbrella term Industrie 4.0 is holding out new, multifaceted opportunities for industry – that much is certain. COO Dieter Schäfer and CFO Ludger Neuwinger-Heimes offer their own viewpoints and separately explain how Freudenberg Sealing Technologies is responding to the “Fourth Industrial Revolution.”



**DIETER SCHÄFER**  
As Chief Operations Officer (COO), he is responsible for Operations, Lean Management, Supply Chain Management, and Purchasing.

“INDUSTRIE 4.0 IS NOT A THREAT BUT AN OPPORTUNITY”

**MR. SCHÄFER, THE TERM “INDUSTRIE 4.0” HAS BEEN COINED TO DESCRIBE THE “FOURTH INDUSTRIAL REVOLUTION.” NOW, AFTER THE STEAM ENGINE, THE ASSEMBLY LINE AND THE COMPUTER, WE HAVE NETWORKING. ARE WE IN THE MIDST OF A REVOLUTION?**

As I see it, when experts promise all of us that Industrie 4.0 will boost productivity 30 percent, that we will simply be using smartphones to control factories in the near future, and that products will travel through halls by themselves, the promise falls somewhere between marketing hype and a “brave new world.” We have to see what we are actually talking about, namely from various standpoints: for one thing, the growing digital networking of things; for another, big data, which incidentally is not new; and finally new mathematical algorithms that make it possible to analyze large quantities of data from different sources. To me, the exciting part is that all these aspects are increasingly coming together to create opportunities for boosting efficiency and improving productivity.

**SO IT WILL BE EVOLUTION INSTEAD OF REVOLUTION?**

Industrie 4.0 does not necessarily mean solely that new ideas are reaching the market. It is rather that ideas are being carried out that people have always had in mind but have not yet been able to execute, perhaps because IT systems have not made them possible or that they were too expensive

“GATHERING DATA ALONE IS NOT ENOUGH”

**ARE WE NOW EXPERIENCING AN INDUSTRIAL REVOLUTION, MR. NEUWINGER-HEIMES?**

We are definitely at a point that is just as exciting as the time when electricity first became useful. It was only gradually that the people began to understand what it meant and everything that you could do with it. First it was just the lightbulb that came along. Then came cooling technology and later engines and powertrains. This fundamentally changed the world.

**DO YOU VIEW THE CURRENT TREND SIMILARLY?**

Various trends are certainly coming together. They all fall under a number of somewhat imprecisely used terms: digitalization, the Internet of Things or Industrie 4.0. They include artificial intelligence, machine learning, big data, and the cloud. Together they represent the power of the trend and the depth of the changes. There is definitely hype out there, and a number of things are still being worked out. But processes will fundamentally change, especially in the world of work.

**BECAUSE WE WILL BE NETWORKED?**

Because business models are radically changing. Take 3D printing: Today, with 3D scanners, you can measure the insoles

**LUDGER NEUWINGER-HEIMES**  
As Chief Financial Officer (CFO), he is responsible for Finance, IT and Mergers & Acquisitions.



and complicated. We are now seeing a stronger linkage between information and interrelationships. And this permits completely new dimensions of thought and action – beyond a person’s obvious perception.

**WHAT DOES THIS MEAN FOR FST?**

I think that almost every company is trying to get closer to this issue and to clarify it: What are our connecting points? What are our options? In our case, this has meant a series of pilot projects in very different subject areas along our entire value chain: from sales to our production and logistical processes. In one pilot project, we analyzed our customer relationship data from a range of years: Who ordered what – and when? Online or offline? What was our delivery performance? For the first time, we were able to lump together more than 150 different aspects of this kind, to find the circumstances that determined whether or not we were actually successful with a customer query. And we can now take measures based on this insight. Or take material flow as another example. Until now, there was no system that could communicate real-time knowledge. It is only indirect knowledge that is continually corrected with stock-taking or inventory reconciliation. Recording data in real-time and processing the information in a meaningful way were much too expensive and complex five years ago. Sensors and cameras can do it today.

of shoes more precisely than any pattern. When people can print complete, individually tailored shoes, delivery services will no long be shipping them. That will change logistics chains and influence entire industries.

**THE WORLD OF PRODUCTION IS CHANGING?**

Many things will change – at a minimum. In the future, a product or raw material might not even enter the factory – instead, software will merely be loaded for printing. But wherever transportation is still taking place, its timing can be more precise than ever before – thanks to networks. Everyone has to give thought to these concepts, and we’re no exception. Maybe we simply make the machine, the material and the engineering services available, and the customer prints out the seals himself. Or we just sell the technical designs.

**AND NO ONE SHIPS INDIVIDUAL PARTS ANYMORE?**

Just consider the expense that shipping represents today. A man in Australia is standing at his machine and needs a seal. He calls the dealer, and the dealer calls us. The seal is manufactured in Germany and then shipped. How much simpler would it be if he could print his seal out immediately with the material kit that he has on site.

**WHAT YOU ARE DESCRIBING IS STILL A VISION OF THE FUTURE. WILL IT TAKE MAJOR INVESTMENTS TO PREPARE ADEQUATELY FOR THIS POTENTIAL UPHEAVAL?**

Interestingly, the trend is toward people increasingly leasing and only paying for what they use: software, infrastructure, services. That’s changing the business environment as well. There were previously barriers to entry for small firms – today they don’t need an initial investment. They no longer need 10,000 euros to buy a server. That’s why there are so many startups successfully challenging established companies.

**BUT EVEN LARGE COMPANIES BENEFIT FROM MORE KNOWLEDGE.**

Naturally. We can create better forecasts and projections. In the past, it had always been a problem if the production planner planned a batch of 1,600, and the machine could only produce a maximum of 1,200 units. In the future, the machine will precisely calculate what it costs in terms of time to produce the extra 400 units. Many issues are a question of time today: the right material mixture, the tool, the stamped part, the preparation. But there is something you can’t work out in your head: Production starts precisely when everything is ready. There’s always a time lag. But in the future, computers will be able to process all these data sets. Data collection alone is not enough.

“MATERIAL FLOW AS AN EXAMPLE: SO FAR THERE HASN’T BEEN A SYSTEM THAT COULD COMMUNICATE REAL-TIME KNOWLEDGE.”

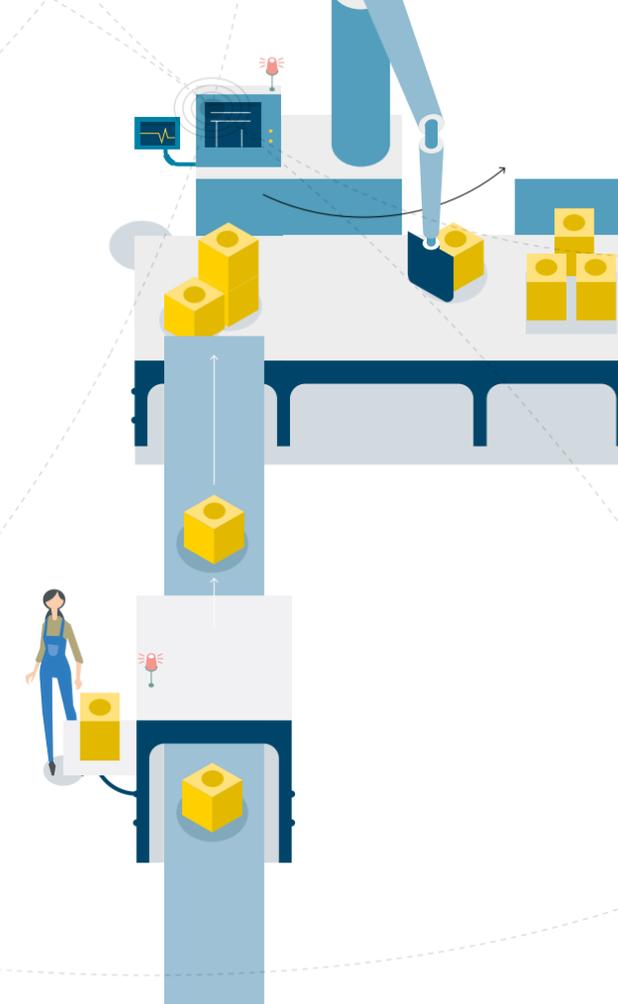


**SO IN THE FUTURE, WE WILL HAVE MORE PRECISE KNOWLEDGE ON MATERIAL INVENTORIES?**

Yes, but not only that. We process elastomers, which are natural raw materials. There is a timeframe in which they are ideally used. Otherwise, heat or the duration of transport can alter their quality. It would be ideal for us to collect all relevant information during the individual processing steps as well as during transport, that is, what is exactly happening to the material and what its condition is when we process it, so we can adjust the manufacturing equipment to the material characteristics as well as possible, even as early as the material’s arrival. With this knowledge, we would not only achieve an edge in quality. We would benefit from optimized material usage and forming processes.

**BUT THE COMPLETELY ROBOT-CONTROLLED “SMART FACTORY” WITH NETWORKED MACHINES IS NOT REALLY AN ISSUE FOR FST?**

Our production processes are not interlinked as tightly as those of the auto industry, nor in such highly complex ways. But we also work with machines. In a test series at one company, the Fraunhofer Institute observed an assembly line with high resolution cameras. Then the images were analyzed using algorithms. The assembly line was reconfigured, and the overall equipment efficiency, or OEE for short, was ultimately raised about 15 percentage points. But since this line was very complex and had an extremely wide range of linkages, no one was able to figure out exactly why the new arrangement is better. We carried out a similar project at our company, at the Berlin plant. Here the OEE was already at 90 percent, and we had already exhausted everything with our familiar tools, process technology and lean ideas in boosting this figure.



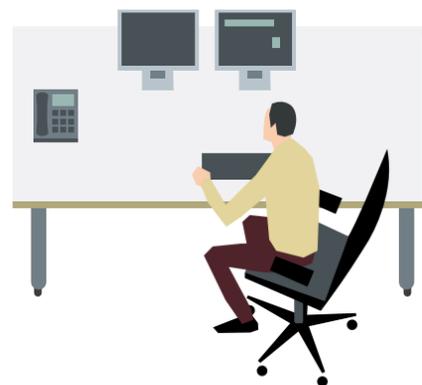
**BUT HASN’T THAT ALSO BEEN TRUE IN THE PAST?**

You previously had to know precisely what you wanted to compute. Today you can just collect, examine and evaluate all the data and then ask: Does this make sense? The power of the new concepts lies in the immense linkage that becomes possible. Capturing huge quantities of data using sensors and then evaluating the information – that has not existed. Or it would’ve involved an immense investment. Today you rent ten minutes of computing services on a server to do this.

**THAT BRINGS US TO IT SECURITY.**

That is naturally an issue, but providers live and die on the security of their data. People were skeptical at first as to whether their money was safer in the bank or at home. There is no question that we have to invest in security. But cyber-attacks are becoming an area where we can better understand the risks and live with them. After all, we drive cars even though there is no 100 percent protection against fatal accidents.

“SIMPLY EVALUATE ALL THE DATA AND THEN ASK: DOES IT MAKE SENSE?”



With the help of the Fraunhofer Institute, we recorded the production process on identical models of various machines with cameras, and disassembled the entire 14-second cycle into 19 sub-steps – meaning below the seconds range in the measurement data. Our classic methods don't work here. The camera lens surpasses the human eye in this case. The image data migrates into algorithms.

**AND THE RESULT?**

There were machines that carried out certain sub-steps out of the nineteen more quickly, perhaps because someone, in an isolated case, changed the adjustments minimally in the hydraulic system or the valves in the past. Thanks to an integrated analysis of the data streams from the image and machine data, we were able to develop a production process, based on the best of the nineteen sub-steps, in which the "assembled" machine operates about 10 percent better than the others. Even two to three percent would've amazed me. But if already efficient-running series production runs offer this kind of potential for improvement, you can assume that just as much potential is lying dormant at other locations.

**SO THE STRENGTH OF INDUSTRIE 4.0 LIES IN ITS ABILITY TO GATHER NEW KNOWLEDGE IN THE FORM OF NEW COMPREHENSIVE DATA, WITH THE DIFFERENT KINDS OF INFORMATION SET IN RELATIONSHIP TO ONE ANOTHER.**

Basically, yes. But it's important to realize that this is not a cure-all. It shows us how processes can be optimized. We are always optimizing, and I don't need Industrie 4.0 as a buzzword to do that. But we were not previously able to capture and measure the data in production processes in microseconds and process it further as actual data, in order to control the particular process more effectively. But if I want to integrate this into an everyday routine, I have to build up capabili-

**WHAT DOES THIS ALL MEAN TO FST?**

I think we are very well positioned. Senior management has dealt with the issue in detail and is ready to learn how to use the new tools and to develop useful applications with targeted experiments. We are ready to make investments and continue training our employees. They are looking forward to this pioneering concept, and we are opening up opportunities to deal with it. But we must learn to differentiate between the hype and the developments that support our sealing business in the long run.

**IS IT ALREADY POSSIBLE TO SORT OUT THE HYPE?**

We have to try a number of things out. With any new technology, you have to learn how to use it. When PCs appeared on the market, everyone was asking themselves: "What is a household supposed to do with a computer?" Then a few games came along, and people began to write letters using it. Then the Internet came along. And now, if a computer stops working at home or at work, "the world comes crashing down."

**SO TODAY WE STILL CAN'T IMAGINE WHAT WE COULD EVER USE THE TECHNOLOGY FOR?**

That is normal. Initially, with a new technology, you often try to reproduce what you know. The result: We print parts with the 3D printer, to cite one example, but they can be manufactured less expensively with conventional processes. As soon as we begin to understand and scrutinize the processes, everything changes. For example, because the printer does not have to adhere to popular geometries. You can't bore around corners, but you can print a spiral cavity. Entirely new forms suddenly become conceivable. Anyone who manufactures or performs a service will have to carefully examine the effects of these new technologies on his business model.



“IT IS THE COMBINATION OF ALL THESE DEVELOPMENTS.”

ties in analysis, methods and algorithms, by hiring data analysts, for example. Our IT and technology infrastructure must be able to handle these digital requirements. And that doesn't come at the push of a button.

**SO YOU ARE MAKING THE CASE FOR REGARDING THE TOPIC CALMLY?**

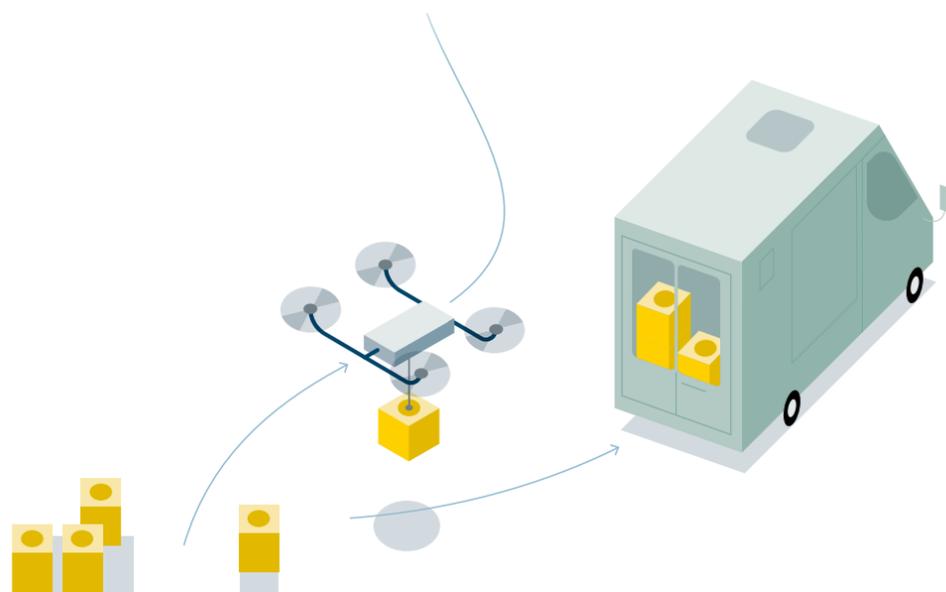
I am making the case for seeing the topic as an opportunity to advance our business model and our processes, which has always been our standard. Industrie 4.0 can be a tool for that. It's certainly not what people sometimes claim it is – that anyone who doesn't play a role in bringing Industrie 4.0 to excessive limits will soon be out of the picture. But it offers great potential that every company should recognize and utilize individually and systematically. Without this impetus, I would not have launched some of the projects now underway – such as the project in Berlin. Nonetheless you have to always question, for example, whether we are really getting benefits from the new data-based knowledge that justify the expense. It is essential to answer that question. To me, it is an exciting area that offers us the potential to improve, as other conventional approaches and methods do. ©

**DO WE NEED TO SEEK OUT WHAT IS NEW?**

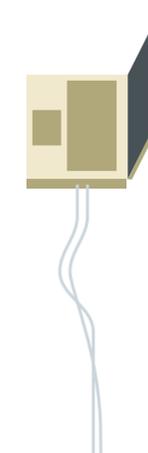
The main idea is that a great many things are coming together. Sensors have been around for a long time. So have data lines. But now numerous small streams are flowing into an ocean. It is the combination of all these developments. In ten years, I don't believe that there will be very many workers standing at machines and performing conventional tasks. But this isn't coming overnight. We still have the time to gear up for the changes that are needed. Ignoring the trend won't help.

**SO WE HAVE TO RETHINK EVERYTHING?**

A major challenge definitely lies ahead for society in general. School systems in particular will have to make adjustments. How do you prepare young people for jobs that don't yet exist? There is a point at which the assessment of an innovation changes completely. In the beginning, everyone laughed at electric bikes. Today they are considered to be a trendy, environmentally-conscious means of transportation. That's how we should look at digitalization: It will make life easier and better in many areas. We should be open to it and take advantage of the opportunities. ©



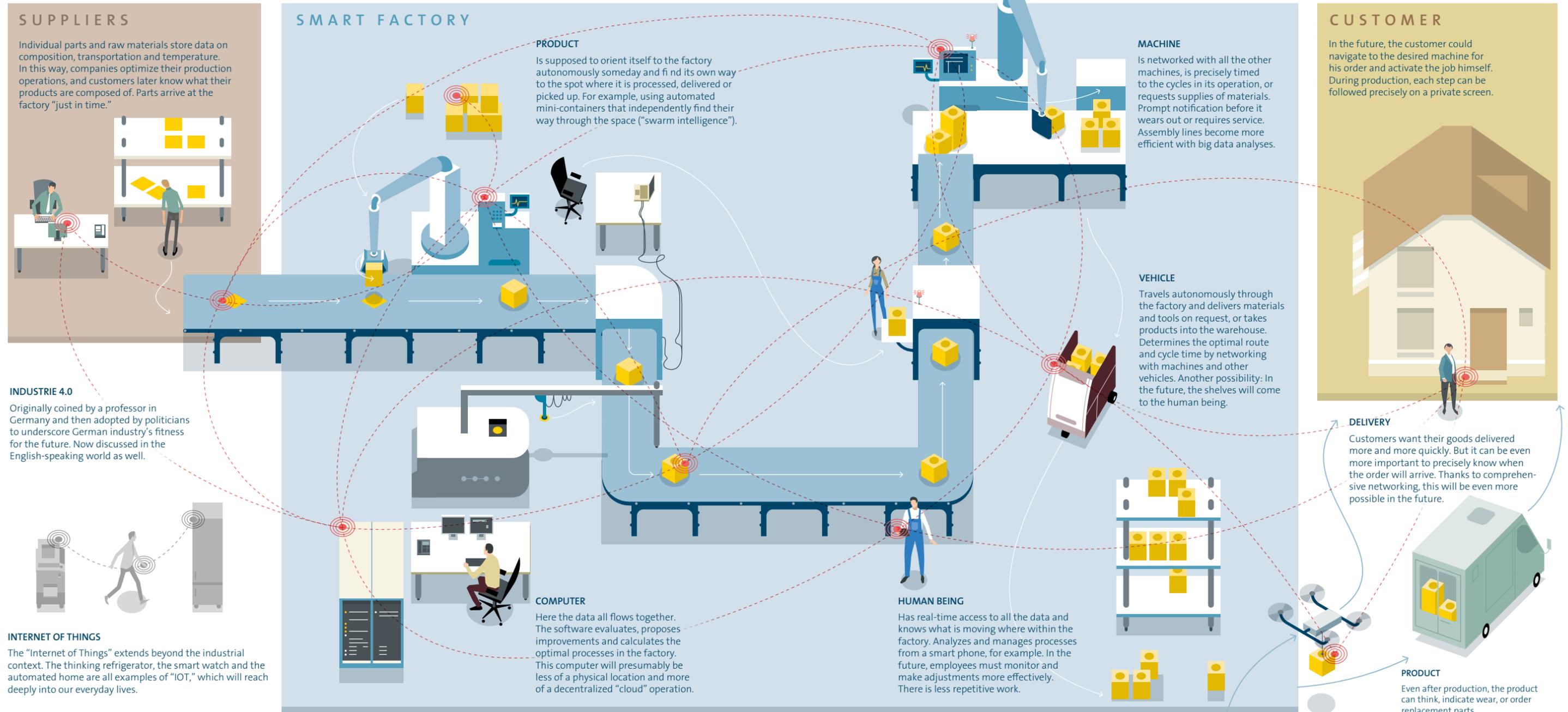
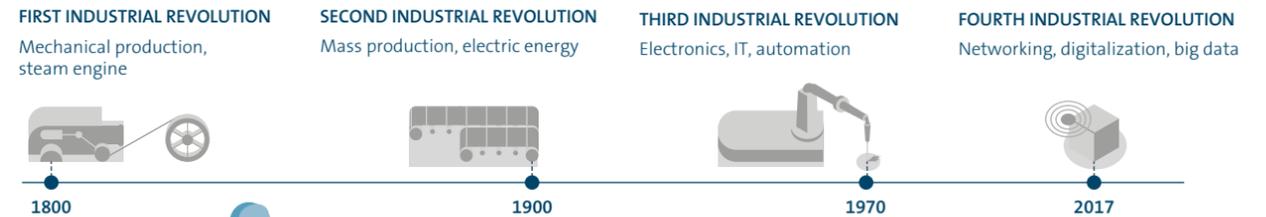
Read the complete interview with Dieter Schäfer at [www.fst.com](http://www.fst.com)



# INDUSTRIE 4.0 AND THE "SMART FACTORY"

"Networking" is the buzzword for the so-called Fourth Industrial Revolution: By networking machines, human beings and products with one another, entirely new opportunities are being developed for the evaluation of data, the optimization of processes and the use of information. Our infographic clarifies where the changes are emerging and what might be possible in the future.

## ON THE WAY TO "INDUSTRIE 4.0"

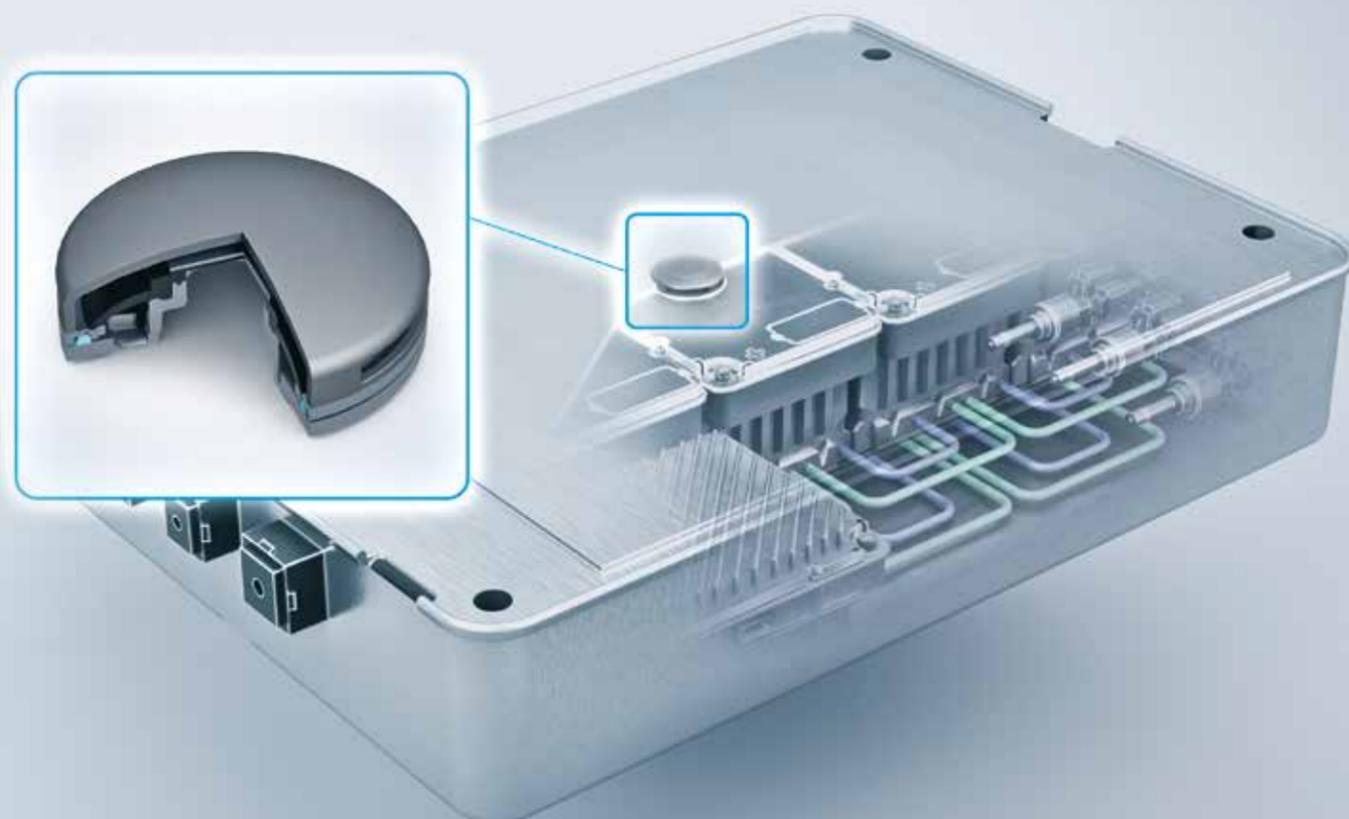




# HOT AND COLD



The electric car of the future is supposed to travel fast and far – and charge up even more quickly. But it’s a sporting challenge for the lithium-ion battery on board to deliver what the customer is looking for. With some cool calculations, Dr. Peter Kritzer gives some thought to the ways that battery overheating can be prevented.



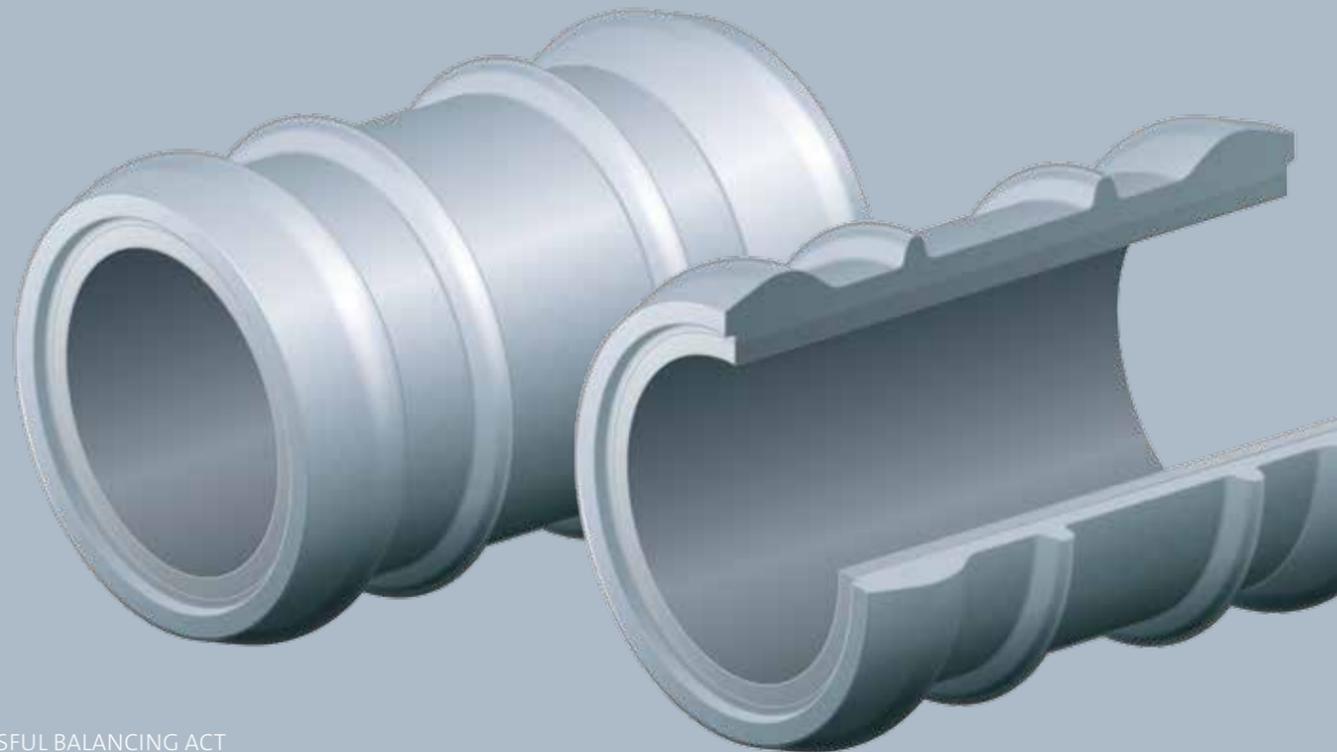
The elegant coupe accelerates from zero to 100 km/h (62 mph) in four seconds. If you wish – and are allowed – to keep pressing down on the accelerator, you playfully reach a top speed exceeding 200 km/h (124 mph). On the other hand, if you drive somewhat more tentatively, you won’t need to stop for a fill-up between Munich and Berlin. That may sound like performance data for a classic six-cylinder engine. But the figures are for the purely electrically powered “i Vision Dynamics,” which BMW presented at IAA. The concept car shows where the world is headed. The electric car of the future is not expected to be a rolling declaration of abnegation. Instead, it will be designed to attract customers with a sporty appearance – and without any guilt about soiling the environment with nitrogen oxides or particulates. And, according to Germany’s automakers, long charging times will soon be a thing of the past. Teaming up with Daimler, Ford and Volkswagen, the Munich-based automaker is building up a fast-charging infrastructure on

Europe’s most important transportation axes. The electric current is expected to flow into the battery with an output of 350 kW – 100 times what an alternating current connection at home provides.

Deep in their bodies, electric vehicles such as the i Vision Dynamics carry the highly developed lithium-ion batteries whose power and energy densities will have doubled by the start of the coming decade, although the cell chemistry will basically be no different than the current state of the technology. There is no technical revolution behind the progress that is helping to drive the electric car to its longed-for breakthrough. Instead, it is a multitude of detailed measures, devised by resourceful chemists and engineers. But maximizing the potential of lithium-ion technology also has its downside. The reason: A battery of this type is a “sensitive soul” at its core. It only feels perfectly comfortable in a narrow temperature range between 5 and 40°C (41 and 104°F), where it develops its full power. High temperatures like

**PLUG & SEAL**  
A single component combines connecting elements for the coolant and their sealing.





#### SUCCESSFUL BALANCING ACT

Plug & Seal technology means: Greater cooling without increasing the cooling system's dimensions.

those resulting from fast charging with high current loads not only reduce its functioning – they also cause the cells to age more rapidly. At the other extreme, when the battery is very cold and the current load is very high, the cells can even be damaged long-term. “As a result, the goal of every manufacturer is to keep the battery in the right temperature window,” says Dr. Peter Kritzer, an expert at Freudenberg Sealing Technologies. “When the energy and power densities rise, the thermal management has to be further developed.”

An initial approach is to allow greater cooling without the cooling system's dimensions increasing – since that would bring the power density down again. Freudenberg Sealing Technologies helps engineers master this balancing

act. With its “Plug & Seal” product line-up, Freudenberg Sealing Technologies makes a technology available that combines the connecting elements for the coolant system and the sealing function into one component, while making complex geometric forms possible in a narrow space. Integrated actuators can also control the coolant's direction of flow.

While “Plug & Seal” is already in series production, Freudenberg experts are now meeting with their customers and discussing whether the battery cooling of the future might not be entirely different. For the heat transfer between the cooling system and the battery cell, it is crucial for the contact surface to be as level as possible. Even a tiny production-related misalignment can

significantly reduce the efficiency of the cooling. “It seems obvious to equip the cooling system with a flexible surface, compensating for mounting tolerances,” Kritzer said. “It is important that we continue to rethink the paths that have already been taken.”

Safety requirements increase as the power density rises. For example, automakers are packing more and more cells into electric vehicles. Since the installation space in the underbody is limited, the individual cells are packed more densely. If no countermeasures are taken, the fire risk – triggered by a process that experts call “thermal runaway” – would rise. In the designs of today's lithium-ion batteries, the electron conductors – anode and cathode – are only kept apart by a thin, 20-µm separator. If it is

damaged, the result can be an electrical short-circuit. The released energy will quickly heat up the cell. If the temperature reaches about 100°C (212°F), the separator begins to melt. In the process, additional energy is released, and the heat increases – not just in the affected cell but also in the adjacent cells, where the same process is repeated. At a temperature of 600°C (1112°F), at the latest, the cathode disintegrates, generally releasing highly reactive oxygen. A fire would then be hard to avoid. So things don't reach that point, all batteries in today's electric cars have an elaborate, multistage safety system. “But the same idea applies here as well: rising energy and power densities and the increased charging current require additional measures,” Kritzer said.

Kritzer has already developed ideas for additional safety measures. He is holding a thin elastomer component in his hands. Its surface displays a waffle structure. “This is a heat shield,” he explains. “The heat insulation is largely provided by a cushion of air produced by the surface structure.” The idea – for which a patent has been filed – is currently being thoroughly tested at Freudenberg Sealing Technologies. “It could definitely be the case that we will vary the materials and the structure,”



DR. PETER KRITZER

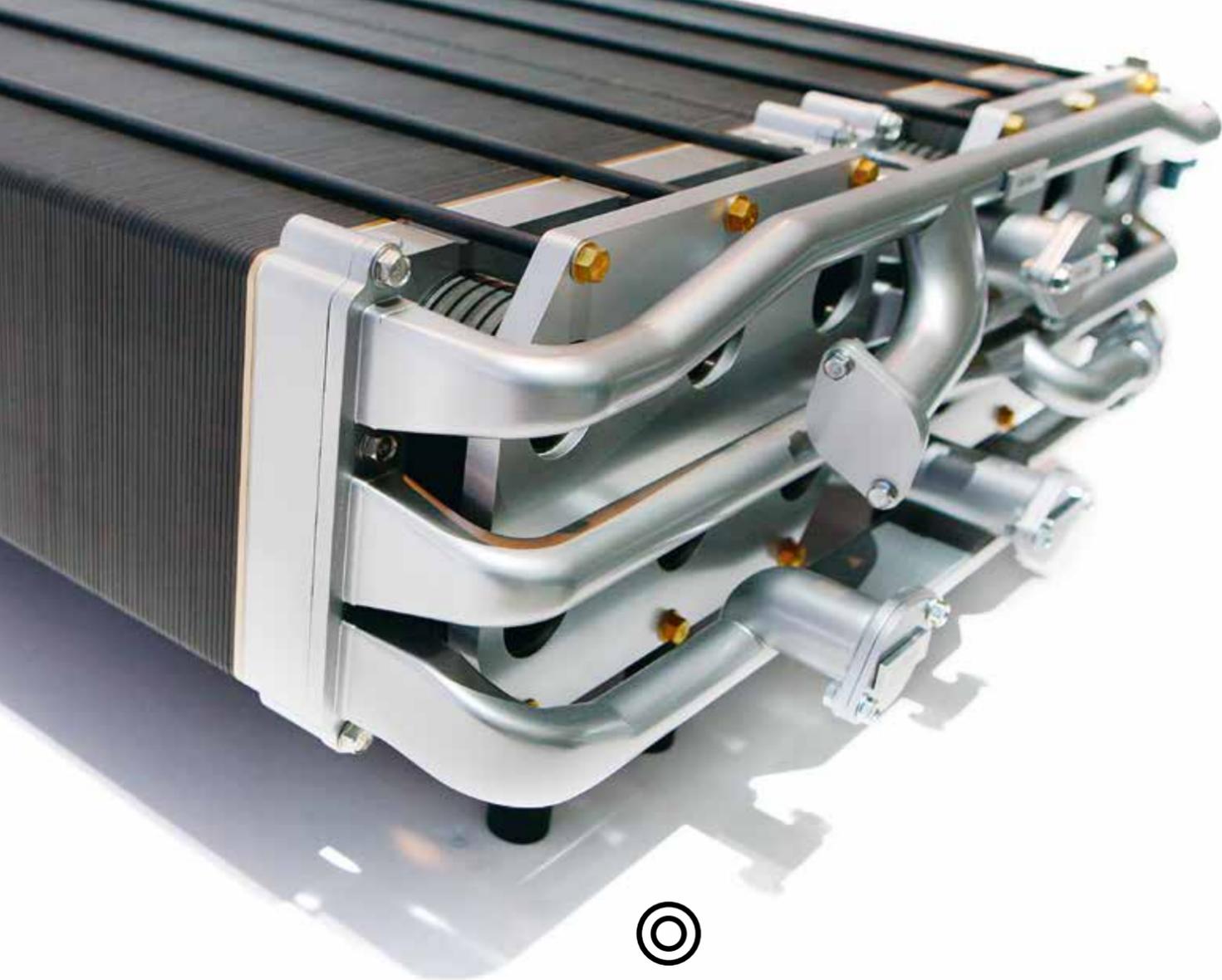
“When the energy and power density rise, the thermal management must be further developed as well.”

Kritzer says. “But we basically consider such heat shields to be a cost-effective and safe solution.”

Another approach would be to use carbon dioxide to quickly cool down an overheated cell. CO<sub>2</sub> reacts extremely slowly – which is why it has long been used in fire extinguishers. In Europe, the first vehicles are reaching the market that have a supply of CO<sub>2</sub> on board – as a coolant for the air-conditioning system. “In an emergency, the CO<sub>2</sub> in the climate control circuit could be deliberately fed to a cell in a critical thermal state,” Kritzer said, explaining a concept patented by Freudenberg Sealing Technologies. “Under pressure, CO<sub>2</sub> cools off considerably during expansion; this could chill an overheated cell with emergency cooling.” The approach is also transferable to vehicles that operate with other coolants. In this case, a small quantity of CO<sub>2</sub> – about 300 grams (10 ounces) – is carried on board in a reservoir. In its technology, the reservoir would be related to the hydraulic accumulators that Freudenberg Sealing Technologies now manufactures in large volumes.

A new valve for the battery housing is significantly closer to series production. For the first time, it combines pressure

compensation during normal operation with the reduction of overpressure during emergency degassing. Developed at the Lead Center Diaphragms, “DIAvent” makes it possible to drain the total amount of gas emitted by a damaged cell and vent it from the battery housing in just a few seconds. This prevents the battery housing from bursting from strong internal pressures that would exceed air pressure many times over. “The rising power density of the individual cells makes it necessary for the emergency degassing to take place much more quickly,” Kritzer said. While the emergency valves have been carried out separately from normal pressure compensation in the past, Freudenberg now combines both functions in a single component. That not only cuts costs but also supports the trend to higher power densities, since a much faster exchange of air – for example, while driving in the mountains – is possible. In the meantime, a variety of automakers are testing the first prototypes of DIAvent. Kritzer considers this a confirmation of his philosophy: “We have to keep asking ourselves whether things might turn out totally differently.” ©



## A FUTURE IN FUEL CELLS



Freudenberg Sealing Technologies  
ramps up serial production of fuel cell components.

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### LEADING THE CHARGE

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As fast as the world is changing, leading companies are working to change faster in order to sustain their technological edge, market relevance and consumer appeal. Nowhere is this more evident than in the complex space that global mobility occupies. Changes in how the world moves goods, services, people – even ideas – are taking place at lightning speed as new technologies and regional needs collide with legislative requirements and environmental concerns.

In response to this important mix of considerations, mobility manufacturers are pursuing multiple powertrain strategies – everything from battery-driven electric motors and smaller, cleaner internal combustion engines (ICE) to hydrogen-powered fuel cells that produce water as their only emission. Whether developing stationary energy systems, construction equipment or a new line of cars and trucks, manufacturers have multiple power options available to help them meet societal expectations. Most experts agree that the mobility landscape of the future will include a substantial mix of all these – and likely others still undiscovered – to meet the needs of the planet.

Freudenberg Sealing Technologies, a global leader in material and sealing solutions for numerous industries, has been implementing strategies to support all of these powertrain technologies. In the small, New England city of Manchester, New Hampshire, the company's latest efforts – development of cost-efficient gaskets that can reliably seal fuel cell stacks – are now in serial production.

The benefits of using fuel cells to generate power for mobility applications are significant. Unlike standard batteries, fuel cells offer the ability to quickly repower vehicles, refueling in minutes and eliminating the downtime associated with charging. Fuel cells also help advance sustainability initiatives. A fuel cell powered forklift has zero emissions, and uses less energy across the full fuel cycle than forklifts powered by diesel, liquid propane gas and lead acid batteries. Fuel cell forklifts do not give off emissions inside a plant either.

Paul Hailey walks through a cluster of engineering cubicles inside Freudenberg's North American gaskets facility in Manchester, pausing briefly to discuss operation of the plant's newest fully-automated production cell. Installed in 2017, the new equipment is dedicated to production of fuel cell seal-on-plate components that integrate an elastomer gasket onto a stainless steel bipolar plate. The customer, a fuel cell manufacturer, combines this component with electrolytic membranes and conductive diffusion layers into an assembled fuel cell stack that powers fork lifts and tow tractors. Engineers in Manchester and throughout the company's global Gaskets Division have been working in concert with the customer to design components that help boost the power and efficiency of the fuel cell system while easing assembly challenges. As head of the location in Manchester, Hailey oversees the collaboration and work.



PAUL HAILEY

With several teams, the head of the “Gaskets” Division has made it possible for the performance and efficiency of fuel cells to improve.

“The needs of our customers are changing, and it’s our job to provide fast, feasible options for addressing those changes,” Hailey says. “In the fuel cell arena, this has meant analyzing exactly how the sealing function of a stack impacts the entire system and applying disciplined engineering tools to develop optimized products. The joint value engineering workshops we have conducted, for example, have resulted in a significant improvement in Manchester’s product portfolio and molding capabilities. With input from the customer and other Freudenberg development partners, this has allowed us to produce a technically-superior design.”

### INNER WORKINGS

Fuel cells are electrochemical cells that convert chemical energy from a hydrogen-containing fuel and oxygen into electricity. A cell consists of an anode, a cathode and membrane with an electrolytic solution that allows positively charged hydrogen ions (protons) to move between the two sides of the assembly. A catalyst dissociates the hydrogen molecule at the anode, producing protons and electrons. The protons flow to the cathode through the electrolytic membrane. At the same time, electrons are drawn out of the anode to the cathode through an external circuit producing direct current electricity. At the cathode, another catalyst dissociates oxygen which then combines with the protons and electrons to form water. Fuel cells require a continuous supply of fuel and oxygen to sustain the chemical reaction that generates electricity.

Because an individual fuel cell produces a relatively small voltage, they are stacked – often in the hundreds and with gaskets incorporated into each layer – to produce sufficient voltage to power vehicles and energy systems. The stacks are compressed and the gaskets hermetically seal the cells, preventing gas leaks, loss of power and cross contamination between the anode and cathode sides of the assembly. The thickness of the seal’s bead also helps prevent the fuel cell components from shifting when they are compressed into a stack.

Fuel cells are classified by the type of electrolyte they use; the electrolyte, in turn, impacts a cell’s operating temperature and startup time. Proton exchange membrane (PEM) fuel cells, in particular, are used in transportation and energy applications because they function well at low temperature and pressures and have a system startup time of mere seconds. Freudenberg’s current fuel cell activities are centered on optimizing PEM systems and delivering a high level of sealing capability with low load characteristics.

### INVESTING IN THE FUTURE

A blue and silver injection molding press that has become the lynchpin of Freudenberg’s serial fuel cell production is surrounded by other manufacturing cells that support the plant’s traditional ICE gasket operations. In a typical year, Manchester will produce 70 million gaskets on more than 150 injection molding presses that range from 50 to 560 tons. More than

350 types of elastomeric gaskets are manufactured and sold to virtually every automotive manufacturer and tier one supplier in the world.

Like all Freudenberg facilities, Manchester has spent decades perfecting the process of analyzing customer requirements and producing technically advanced, high-quality, cost-effective solutions. The facility’s fuel cell operations have and will continue to follow a similar development road, Hailey said, starting with intense business collaboration among several Freudenberg business units nearly a decade ago.

“We have been working on fuel cell technology in concert with Freudenberg Technology & Innovation and Freudenberg Performance Materials for years,” Hailey said. “These organizations have brought significant technical advantages to Freudenberg Sealing Technologies in terms of fuel cell gas diffusion layer developments and functional performance considerations. The collaboration has been invaluable in working with our current customer to identify system solutions.

In addition, Hailey noted, other global Freudenberg Sealing Technologies gasket facilities are contributing to Manchester’s new operations. Stainless steel bipolar plates, for example, are being stamped at the company’s Necedah, Wis., facility and shipped to New Hampshire for final production.

Standardization of this first manufacturing cell is critical because it will serve as a model for future expansion, Hailey explained. In order to ensure that the equipment, programs, materials and processes inside the cell have been optimized, engineers and other key personnel have participated in dozens of technical meetings that analyzed everything from component performance, sealing material profiles and production technologies to design for manufacturing and assembly. All of these factors are application-dependent, Hailey added, and have required Freudenberg to form a robust technical partnership with the customer to make the best decisions.

“Our customer is depending on us to offer innovative components that contribute to the advancement and success of their products. Our strength is in our ability to anticipate market needs by using the right materials, designs and innovations to set a benchmark for future growth,” Hailey concluded.

As applications for fuel cell technology grow, Freudenberg will continue to ramp up its capabilities. The engineering and material expertise on which it has already founded a solid ICE sealing legacy will carry it to new success. Manchester’s operations now serve as the blueprint for the company’s other global gasket plants to engage in fuel cell component production. The company will continue to embrace change as the mobility landscape continues to evolve. ©

### INNER WORKINGS

Fuel cells are electrochemical cells that convert chemical energy from a hydrogen-containing fuel and oxygen into electricity.






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# AFTER 85 YEARS, NOT A BIT OUT-OF-DATE

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THE FREUDENBERG TANNERY  
the largest leather manufacturer in Europe in 1929

The Simmerring: It is no longer possible to imagine vehicle technology and machine-building without it. In 1932, the shaft seal ring developed by Freudenberg was still made of leather scrap. Today it is constructed of high-performance elastomers that contain sensors. As a result, it is well on its way to new episodes in its success story.

As the proverb says, necessity is the mother of invention. The example of the Simmerring shows that the old saying has a kernel of truth. As the global economic crisis hit Germany with its full force in 1929, the leather industry, like other sectors, was unable to escape it. Freudenberg, then the largest leather manufacturer in Europe, was right in the middle of the crisis. To survive it – which threatened the company’s very existence – the management decided to position the company more broadly. It gave engineer Walther Simmer an assignment: to develop a sleeve seal that could be produced from leather remnants. A sample of a sleeve seal from the United States served as the inspiration. The product offered the prospect of good sales since the then-expanding auto industry needed it.

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## AN IMPRESSIVE NEW PRODUCT

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The Simmerring, which was named after its developer, reached the market in 1932. It could be firmly incorporated into the sheet metal housing that surrounded the drive shaft. This made the new shaft seal ring considerably more reliable and higher-performing than the felt strips used previously. With the help of a worm spring and the impregnation of the leather with a rubber-like material known as acronal, further improvements in the contact pressure and elasticity could be achieved. Starting in 1936, Freudenberg began to manufacture Simmerrings based on the synthetic rubber Perbunan. They exhibited greater resistance to high temperatures and

mineral oil. Both features were important characteristics for the still-booming auto industry. Over the next few years, Freudenberg also adapted the Simmerring’s seal lip to particular uses.

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## MAKING GOOD THINGS EVEN BETTER

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Its status as a top seller was underscored when the 100 millionth Simmerring left a Freudenberg production facility just 21 years after its invention. But true to the notion of making good things even better, Freudenberg continued to refine the product. It was especially progress in the use of materials that elevated the shaft seal ring to ever-higher development levels. In 1980, the

sleeve was made from the plastic polytetrafluoroethylene (PTFE) for the first time. The modified Simmerring was impressive for its resistance to almost all oils and additives. It also remained flexible at temperatures between  $-40^{\circ}\text{C}$  and  $260^{\circ}\text{C}$  ( $-40^{\circ}\text{F}$  and  $500^{\circ}\text{F}$ ). That made it the first choice for use in internal combustion engines.

### SMART COMPONENT

Freudenberg didn't relax after the success of its top product. It was a matter of continually planning ahead for developments in the industry so it would have the appropriate seals ready at the right time. For example, increasingly compressed installation spaces in ever more compact equipment required smarter components. That's why a Simmerring with a magnetized elastomer layer was brought out in 1997. It allowed sensors to gather detailed operating data on sealed shafts. For example, anti-lock braking systems (ABS) turn to its data. Engine management can also be improved through the information's use. The Simmerring has thus outgrown its original purpose: merely the sealing

of rotating shafts. It now contributes to driving safety as well. In addition sensors installed in the Simmerring now help identify the right interval for their replacement. This helps to cut maintenance costs.

### ECOLOGICAL EFFECT

The Simmerring even contributes to the protection of the environment. In the increasingly widespread hybrid and electric vehicles, it is fundamental to avoiding electrostatic charging between housings and shafts. When Simmerings are furnished with a conductive non-woven, this charging is effectively prevented. By contrast, modern internal combustion engines have to get by with less and less energy, which reduces emissions. But at the same time, engine output is supposed to climb. The reduction of friction is the puzzle piece that helps to satisfy all these desires. A modified Simmerring has been shown to be the appropriate solution here as well. Developed in 2012, the mechanical face seal Levitex relies on a self-generated cushion of air. In this way, the seal fulfills its original purpose – preventing leak-

age – while generating the least possible friction. The result: less wear, a smaller decline in output, and a longer operating life.

### FROM TINY TO HUGE

Since sealing systems are not exclusively used on a large scale but in micro drives as well, Freudenberg is pressing ahead with the miniaturization of the Simmerring. The smallest model has the job of sealing rotating shafts with a diameter of just 1 mm – at more than 10,000 rpm. They are used in devices for blood analysis and adhesive dosing. From micro pumps all the way to rollers in steel mills, the Simmerring has become a reliable solution in every conceivable application. The shaft seal ring once manufactured from leather scrap is a high-tech product today whose key functions go far beyond sealing. This demonstrates that the Simmerring has been enormously versatile over its 85 years and has not gone out of fashion down to the present. Congratulations to the Simmerring on its 85th birthday! ©

#### A TRADITION OF INNOVATION

The success story of the Simmerring continues. Like its history, its future will be driven by Freudenberg's dynamic technical developments and technological competency.



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## IMPROVED TUBE CONNECTIONS

**Clamp seals are fast and especially reliable tube connections in continuously operated production facilities. Freudenberg Sealing Technologies has developed a new clamp seal that seals reliably and eliminates the need for the costly conversion of connections with the "hygiene flange" in accordance with DIN 11864. It also prevents over-compression on the inside, providing a secure and hygienic tube connection.**

Conventional clamp seals have no predefined compression. The result is that a portion of the clamp seal protrudes into the interior of the tube connection when a flange connection is sealed. The inner diameter of the tube becomes smaller and obstructs complete cleaning – a critical factor in the food and processing industries. The flow of media can also lead to seal damage or the protruding parts of the seal could be torn off and enter the product.

Freudenberg Sealing Technologies has developed a new clamp seal for tube connections in accordance with DIN 32676, ASME BPE or ISO 2852. Thanks to a plastic part incorporated into its interior, it has a defined stop. This prevents unwanted extrusion into the line's interior. The seal closes almost flush with the tube. The interior diameter of the seal remains precisely the size of the tube. The conversion of all connections to the "hygiene flange" in accordance with DIN 11864 can be avoided. Thanks to the use of plastic as the stop, it is possible to do without additional bonding agent, which would be necessary with metal, for example. ©



## SELF-MONITORING SEALS

**Seals increasingly must do more than just seal. In the future, they will be expected to forecast when they will malfunction and thus permit condition monitoring in real time. In this regard, Freudenberg Sealing Technologies is working on solutions, for example, for a new generation of smart seals for use in the food and processing industries. The areas of application for this type of seal are nonetheless multifaceted.**

Seals are mostly made of materials that, in their pure form, cannot process signals. That's the reason that development engineers at Freudenberg Sealing Technologies are exploring materials that can turn seals into sensors or even actuators, for example – and do it without impairing the seal's original task. Special material compounds are coming under consideration for this. With an appropriate design, the seal can communicate the extent of its wear, and the information can be linked to system data.

This makes it possible to predict when the seal in question should be changed. This is an important capability for predictive maintenance – one of the core components of Industry 4.0. Another factor is equally positive: Operating costs can be optimized since the seal can be used over its entire lifespan – and would not be replaced prematurely. In this way, it is possible to plan maintenance intervals proactively and make them mandatory. On the other hand, subsequent costs due to leakage-related damage – which result when seals are removed too late – are avoided. ©

## FEEDBACK & CONTACT

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**EDITORIAL**  
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Redaktionsbüro delta eta

**DESIGN & CONCEPTION**  
Profilwerkstatt GmbH

**PRINTING**  
ABT Print und Medien GmbH  
Bruchsaler Straße 5  
D-69469 Weinheim

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SETTING QUALITY BENCHMARKS.

# 165 YEARS EXPERIENCE

FOR MATERIALS THAT RESIST  
EXTREME CONDITIONS



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