



ESSENTIAL

FREUDENBERG SEALING TECHNOLOGIES
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0 0 0   0 0 0 0   0 0 0
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ONE ZERO ONE

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DIGITALIZATION

THE LAND OF DATA

An interview with Estonia's former CIO about the digitalization of a nation.

BUTTER AND BYTES

Why a baker sees automation as the only chance for manual trades.

TRANSPARENT PRODUCTION

Controlling factories with IT and tablets. How data make planning easier.

THE BINARY CODE ALPHABET

Binary code uses just two symbols to present information: "true" and "false" or 1 and 0. Gottfried Leibniz is credited with the code's invention in 1689. An 8-bit code is shown below.

0	0011 0000	O	0100 1111	m	0110 1101
1	0011 0001	P	0101 0000	n	0110 1110
2	0011 0010	Q	0101 0001	o	0110 1111
3	0011 0011	R	0101 0010	p	0111 0000
4	0011 0100	S	0101 0011	q	0111 0001
5	0011 0101	T	0101 0100	r	0111 0010
6	0011 0110	U	0101 0101	s	0111 0011
7	0011 0111	V	0101 0110	t	0111 0100
8	0011 1000	W	0101 0111	u	0111 0101
9	0011 1001	X	0101 1000	v	0111 0110
A	0100 0001	Y	0101 1001	w	0111 0111
B	0100 0010	Z	0101 1010	x	0111 1000
C	0100 0011	a	0110 0001	y	0111 1001
D	0100 0100	b	0110 0010	z	0111 1010
E	0100 0101	c	0110 0011	:	0011 1010
F	0100 0110	d	0110 0100	;	0011 1011
G	0100 0111	e	0110 0101	?	0011 1111
H	0100 1000	f	0110 0110	-	0010 1110
I	0100 1001	g	0110 0111	,	0010 1111
J	0100 1010	h	0110 1000	!	0010 0001
K	0100 1011	i	0110 1001	„	0010 0010
L	0100 1100	j	0110 1010	(0010 1000
M	0100 1101	k	0110 1011)	0010 1001
N	0100 1110	l	0110 1100	space	0010 0000



ONE. ZERO. ONE.

1 / 0: What's Really Behind Digitalization?

Ones and zeros. At their core, our computers have been based on a binary code, on a duality that is downright seductive in its simplicity: on or off, true or false. At the same time, our digitalized world today has nothing in common with the computing machines devised by Leibniz, who computed with a binary numbering system back in the 17th century. Or with the first digital computer invented by Konrad Zuse in 1941. It filled an entire room. Or the first home computer whose keyboard alone weighed three kilograms. Today computers fit in the pockets of your pants or are worn on your wrist. We entrust our computers and our nuclear power plants to computer code. Entire manufacturing operations are based on programmable controls. There is hardly a film that has not been processed on a computer. And all this with a technology that at its core is based on ones and zeros.

TODAY COMPUTERS FIT IN THE
POCKETS OF YOUR PANTS OR
ARE WORN ON YOUR WRIST.



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As this historical overview suggests, digitalization itself is basically not new. The rise of the computer took place a long time ago, and the world has been digitalized for decades – since digitalization simply means that information exists in digital form, whether it involves text, music or construction plans.

DIGITALIZATION ITSELF IS BASICALLY NOT NEW.

So why do we feel we are living in the age of digitalization? And why has digitalization been proclaimed a megatrend? Here's one reason: The digital transformation is primarily not a technological phenomenon – it is societal. The momentum of digitalization in our daily life has swept all of us along for a while. Photos, appointment calendars, shopping lists – an almost unmanageable quantity of everyday objects is digitalized today. The same applies to industrial processes. To be sure, automatically controlled machines are nothing new. But today entire flows of goods are digitalized, along with ordering data and product information. This is creating the foundation for autonomous vehicles, drones that navigate by themselves, and the expectation that work machines will no longer just carry out commands – they will learn to act on their own.

On the other hand, digitalization has a crucial connection with another phenomenon: networking. It is only when digital data are networked extensively that the information actually acquires new value. The more systems are networked with

one another, the greater the benefit. Internet pioneer Robert Metcalfe formulated this rule in 1980, which is why it is known as “Metcalfe’s Law,” if it is known at all. Surprisingly, people are often unfamiliar with it. Metcalfe recognized early on that the cost of a communication system merely grows linearly as the number of participants rises, but the benefits grow exponentially because every new participant can communicate with any person already in the network. This is true whether the networks involve fax machines – still common back in Metcalfe’s day – or a social media channel today. Not least of all, the many contradictions associated with digital networking show how wide-ranging, cataclysmic and at times confusing the trend is.

Safe / Unsafe: A Story of Backups and New Dangers

Digitalization promises us unimagined forms of security. Data can be stored and encrypted multiple times and stored in the cloud, where no flood, fire or even a volcanic eruption can destroy them. Automated machinery and vehicles do their work reliably and safely because they never get tired and always obey the rules, but this safety is closely followed by a new form of insecurity – data theft and invasion of privacy. Suddenly, we no longer feel secure in the safety of our own homes. Due to the issue’s complexity, a vague sense of anxiety simultaneously takes hold. It is much harder for us to figure out what risks we are facing.

Ease of Use/Complexity: More Comfortable Life or Data Labyrinth

Digitalization is simplifying our lives in radical ways. Incidentally, one observation suggests how fundamental the change is: there are almost no science fiction authors who predicted the Internet or the smartphone – although plenty envisioned robots and autonomous vehicles. That means our forebears

IT IS OPENING UP OPPORTUNITIES FOR NEW BUSINESS MODELS, NEW MARKETS AND EVEN NEW PRODUCTION PROCESSES.

could imagine technical aids, but not full-scale networking with its innumerable benefits and continual data availability. Online retail, navigation and same-day delivery offer us unimagined convenience. But at the same time, digitalization complicates our everyday life. The new technologies are overwhelming at times. They make us dependent. They are useful as long as everything runs smoothly. But we are helpless when the technology breaks down, when the navigation software sends us to the wrong location, or when even an attentive reader can no longer tell the difference between truth and falsehood. At one time, a wrench and a tube of all-purpose glue were enough to repair a household appliance. Today it takes an IT expert.

Quantity / Individualization: Ever-Larger Volumes or Increasingly Specialized?

Digitalization accelerates mass production. Thanks to systems that communicate with one another and to autonomous machines that think for themselves, the quantity of goods produced can be increased in many industries. Broadband connections are permitting new forms of cooperation. Development team members who once went on lengthy business

trips now link into conferences online. Development times are shrinking, and companies are drawing greater benefit from their value chains. That is one side of the issue. On the other side, digitalization is enabling an entirely new kind of small-scale, customized production. With the help of configurators, customers are putting their products together with a succession of clicks – whether they are buying a muesli mixture or an automobile. Not long ago, the customers of most automakers could choose between three colors and perhaps two different engines. Today, with its multitude of options (including 156 steering wheel variations), VW says it could theoretically build one septillion vehicles, each with different details. That’s a figure with 24 zeros.

One or Zero: Or Both? The many dichotomies simply prove how massive the upheaval really is. The idea of digitalization involves more than a single phenomenon. It is still not quite the correct term semantically, as we have seen. Quite a number of other buzzwords are pulled along in its slipstream with the usual conceptual fuzziness, including Industry 4.0, virtual reality and artificial intelligence.

At Freudenberg, we see digitalization as a comprehensive issue. For our part, it is opening up opportunities for new business models, new markets and even new production processes. In addition, thanks to digital simulations, new products can be developed and manufactured, for example. The current edition of ESSENTIAL covers the length and breadth of what is possible. It pays a visit to digital pioneers, tours digitalized plants and introduces seminal ideas. Because we are convinced of digitalization. In any case, there is one thing that we know a great deal about: the fact that essential technologies and innovations come from small, nondescript things, like individual ones and zeros. Or even a tiny seal. ©



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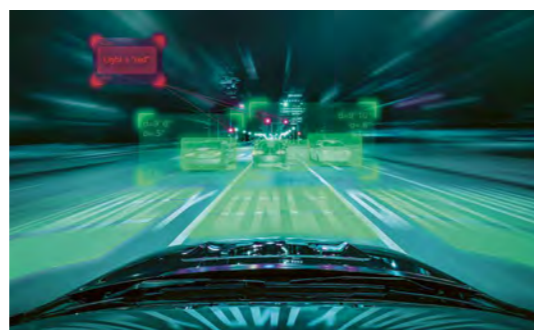
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IN AN INSTANT

Cashless payments are on the rise in ever more countries. In Sweden, some banks are completely doing without cash dispensers. Instead, people are paying with cards or by smartphone at bakeries or for public transportation. But that doesn't come close to exhausting the possibilities. Special implants are now getting attention.

Tens of thousands of people worldwide are already thought to carry a rice-grain-sized chip beneath their skin. They can use it to pay for purchases, store personal data or use equipment in a fitness studio. The data recorded on the chip can be scanned by contactless reading devices.

It is a technical development that people still regard skeptically. It literally gets under their skin.





R2-D2 IN THE COWSHED

Not everyone associates the keeping of livestock with digitalization, but when fewer farmers are caring for more and more cattle, automated processes are only logical. The activities are controlled by app. The cows enter the milking stations of today's cowsheds on their own. Robotic arms extract the milk with the help of sensor controls while the app indicates volume and quality. The cows are fed by feeding robots. They gather the feed components in portions that the farmer preprograms before they mix them and deliver them into the stall. It is even possible to create customized mixtures for individual cows. Chips record the behavior of the animals, from rumination to movements. This makes it possible to identify signs of illness early. Fully transparent dairy cows are already a reality.





ONE-TO-ONE — DIGITAL TWIN

More and more companies are working with a digital model of a real product or production process, as this simulation at the Hannover Messe showed in 2018. The data collected by sensors are translated into a congruent 3D model in the cloud.

Functions of the original are depicted graphically and monitored in real time. This kind of coupling of the two worlds offers still other advantages. While the original is functioning, various scenarios can be played out in the digital version to see the impact of modifications, for instance, or the maintenance strategies that are available. This leads to minimized sources of error and shortened development cycles. The companies' productivity grows. Employees can also save time by using the digital twin for training.



“WE CAN ALWAYS REBOOT OUR COUNTRY”

In 1991, barely half of all Estonians had a phone connection. Today, there is hardly a country that is as systematically digitalized as Estonia. Taavi Kotka was the first Chief Information Officer (CIO) for the government of Estonia through 2017. We spoke to him about Estonia’s need to digitalize, its digital society and his conviction that countries like Germany and the U.S. have to follow their example.

TAAVI KOTKA, CONGRATULATIONS ON THE BIRTH OF YOUR FOURTH CHILD. YOU TWEETED AN IMAGE FROM THE HOSPITAL THAT SHOWED A WRISTBAND WITH A BARCODE ON YOUR CHILD’S ARM. WHAT WAS THAT ABOUT?

When a baby is born in Estonia, the government names the baby first and then the parents have two weeks to figure out what the baby’s given name should be. When I say that the government names the baby, I mean that the government gives a unique identifier to the child, a digital name that is also written down on the wristband. Every newborn gets one. All the data that are created and connected with the child, the birth record, the patient record or whatever information now starts to exist will be connected with that digital identity.

SO THE UNIQUE IDENTIFIER IS THE DECISIVE TRIGGER?

Exactly. In the digital world, your names have to be unique. It’s like your mobile number and your email address, they are also unique. We have agreed that every Estonian has a unique identifier from his or her very first breath. That’s why I showed the wristband of my baby boy to show the world that this is something essential for our society. The unique identifier

was instantly issued by the population registry that is our key registry. All the other registries need to refer to that particular one.

AREN’T THERE ANY CONCERNS IN YOUR SOCIETY ABOUT THIS COLLECTION OF DATA?

There’s a huge difference between how Germans or people from the UK see privacy and how Nordic societies in Scandinavia and Estonia do. In Germany, you simply don’t know who has had a look at your patient record. You don’t have a clue because you are not able to control your data. In Estonia, we mean that connecting data is not the problem. What counts is having control over our data.

AND YOU HAVE IT?

Yes. I can see who has had access to my data. As long as the regulation doesn’t say otherwise, I can cover my data so that no one else has access to it. And I can always ask the Ministry for the Environment, for example, what kind of data it created about me. So, for us, the new data protection regulation in the EU has been our life anyway.

TAAVI KOTKA

(born in 1979) started his career as a programmer before rising to be the CEO of a large software development company (now Nortal). In 2013, he became Estonia’s first ever Chief Information Officer (CIO). He oversaw the country’s development as an advanced digital nation until 2017. During his time in office, the e-residency program and data embassies were introduced. Kotka was named European CIO of the Year in 2014. He was also special advisor to the European Commission Vice President Andrus Ansip on the European Digital Single Market. He has now returned to the private sector again, with his fellow engineers at ProudEngineers.com.





DIGITAL IDENTITY
Citizen cards in Estonia
include a clear identifier.

SO WHAT CHARACTERIZES YOUR DIGITAL SOCIETY IN ESTONIA?

When we talk about being a digital society, we don't talk about going from paper to computer. What we mean is a seamless society, where things just happen.

CAN YOU PLEASE GIVE US AN EXAMPLE?

When a child is born, the mother gets child support money. Whenever the nurse puts the baby into the system, the hospital system triggers an event in the population registry. The unique identifier is issued for the child, and the population registry triggers an event in the Ministry of Social Affairs that the mother is supposed to get support money. That's very convenient since most people want to receive the support money anyway. So why should they have to apply for it? To calculate the child support money, the responsible department needs to know the salary and taxes of the mother. Tax and customs deliver that information automatically. It's about issuing requests from machine to machine, no human is involved. The first and foremost step is that everyone gets his unique identifier. Otherwise, our system wouldn't work.

SO HOW DO YOUR ADMINISTRATION AND ECONOMY BENEFIT FROM THE DIGITAL SOCIETY?

First of all, it's for society. The people have control over their data. If I want to remove or cover my data, I can do it in Estonia. Another thing when it comes to digital society is the time saved. In most countries of the world, if you need to sign a contract, you print it out, sign it, pay a courier service to send it

“FIRST OF ALL,
OUR DIGITAL APPROACH
IS FOR SOCIETY.”

to the other party, they sign it, pay the courier service as well to send it back to me. So, both of us spend money and it takes at least a day. How do we do it? We right click, pin it with email to you, you open it, add your pin and send it back. Two minutes. That's it. And, last but not least, we can connect and combine everything. From health care data to financial data to social data, data in agriculture, and so on.

SO THERE'S GREAT TRUST IN YOUR SYSTEM?

When people are used to using certain things or they understand how the system works, the trust gets bigger. Of course, the system can also be abused. A doctor can be evil. But then, we know it's that doctor, since I can easily track in our system who has accessed my data. He gets fired instantly if he queries information without reason. If he passes data to a third person, he goes to jail.

IN 2017, THE ESTONIAN PARLIAMENT CHOSE TO HOST A BACKUP OF ITS MOST IMPORTANT DATA AT A “DATA EMBASSY” IN LUXEMBOURG. WHAT WAS BEHIND THIS DECISION?

When your society is fully digitalized, there's no paper anymore. I don't have my child's birth record on paper. It's in the registry. Digital continuity becomes important for our daily life. So, whenever something bad happens, a natural disaster or a cyber war, we have a backup now. We can always reboot our country from the cloud and continue to run certain services from outside Estonia. If we get hacked, we switch the server off here and turn it on in Luxembourg. It's like with your family photos. You need backups if you want to keep them and we decided to host them outside of our country.

IN OCTOBER 2018, THE ESTONIAN PRIME MINISTER MADE BILL GATES A VIRTUAL CITIZEN OF ESTONIA. WHAT BENEFITS DOES THE FOUNDER OF MICROSOFT NOW ENJOY?

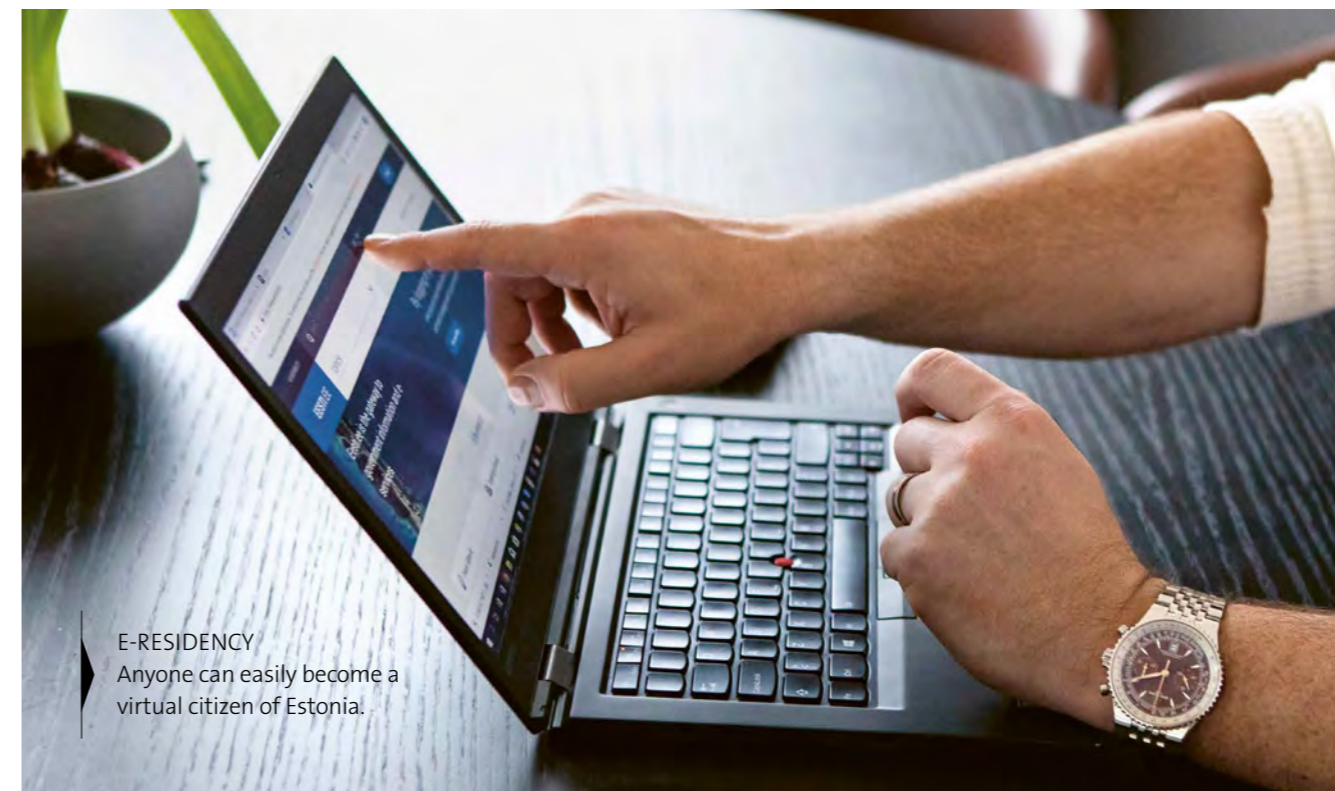
When we invented the e-residency a few years ago, it was pioneering stuff. It's like Spotify versus the CD. You don't buy CDs anymore but use streaming platforms like Spotify because they are more convenient. The question was: shouldn't government services also be seen the same way as Spotify?

SO YOU OPENED YOUR GOVERNMENT SERVICES TO PEOPLE FROM ABROAD?

Yes. If you're a freelancer and run a company elsewhere in the European Union, that often means high costs, huge bureaucracy, it takes lots of time and hassle. If you run a company in Estonia – the same EU, the same European bank accounts, the same speed with bank transactions, and the same MasterCard system – it just costs you €75 (\$85) per month and you don't have to do any reporting, any accounting and your taxes are paid in your native country, so you don't cheat your government. What we want to prove with e-residency is that, in the future, people will start seeing health care services, education and government services as services. And they will grab the ones that are more efficient. With our e-residency, you are like an Estonian. You use the same digital tools and services as me.

SO YOU AIM TO ATTRACT NEW BUSINESS?

The customers of your country are the people and the companies who are connected with your economy. The e-residency program is meant to attract and connect more people all over the world with our economy because, when they operate a



E-RESIDENCY
Anyone can easily become a
virtual citizen of Estonia.

“WE WILL LOSE
HEAVILY TO ASIA,
SO WE NEED TO ADOPT
A NEW MIND SET.”

company here, they need a bank account. And they might end up choosing a bank account from here. And when our banks have more customers, they will pay more taxes.

SOUNDS LIKE A LOCATIONAL ADVANTAGE!

Today, countries only compete to get the best people for their universities or companies. The future will be: how can I connect more customers virtually? Like Spotify versus the CD store. That will be the future competition, and we just show how it works.

E-RESIDENCY IS AN EXAMPLE OF HOW YOUR COUNTRY IS BREAKING OUT OF OLD, ESTABLISHED PATTERNS. IS IT A FEATURE OF THE DIGITALIZED WORLD TO REASSESS CHALLENGES BECAUSE SO MUCH MORE IS POSSIBLE TODAY? AND WHAT DOES THIS MEAN FOR ENTREPRENEURS?

Every decade we have something new that changes the world, right? It's a question of adoption. U.S. companies adopted the benefits of the Internet so much faster. We don't have our European Google, Facebook or Amazon. Why? Because we were just late. The same thing will happen again if we now miss out on digitalization and the digital beneficial society. The good news is that Europeans won't lose to the U.S. They are as bad as Europe. But we will lose heavily to Asia, so we need to adopt a new mind set, a new way of thinking.

IN OTHER WORDS, THE WESTERN SOCIETIES NEED TO WAKE UP.

China and the Nordic countries combine data because they believe that it's needed and it provides better and faster services and allows better decision-making. And there are countries like Germany, the U.S. and the UK where the governments lag behind. It's not only about convenient services or service automation. It's also important what kind of questions you

can answer for a better future. Am I able to connect certain elements, certain registries, to draw the right conclusions?

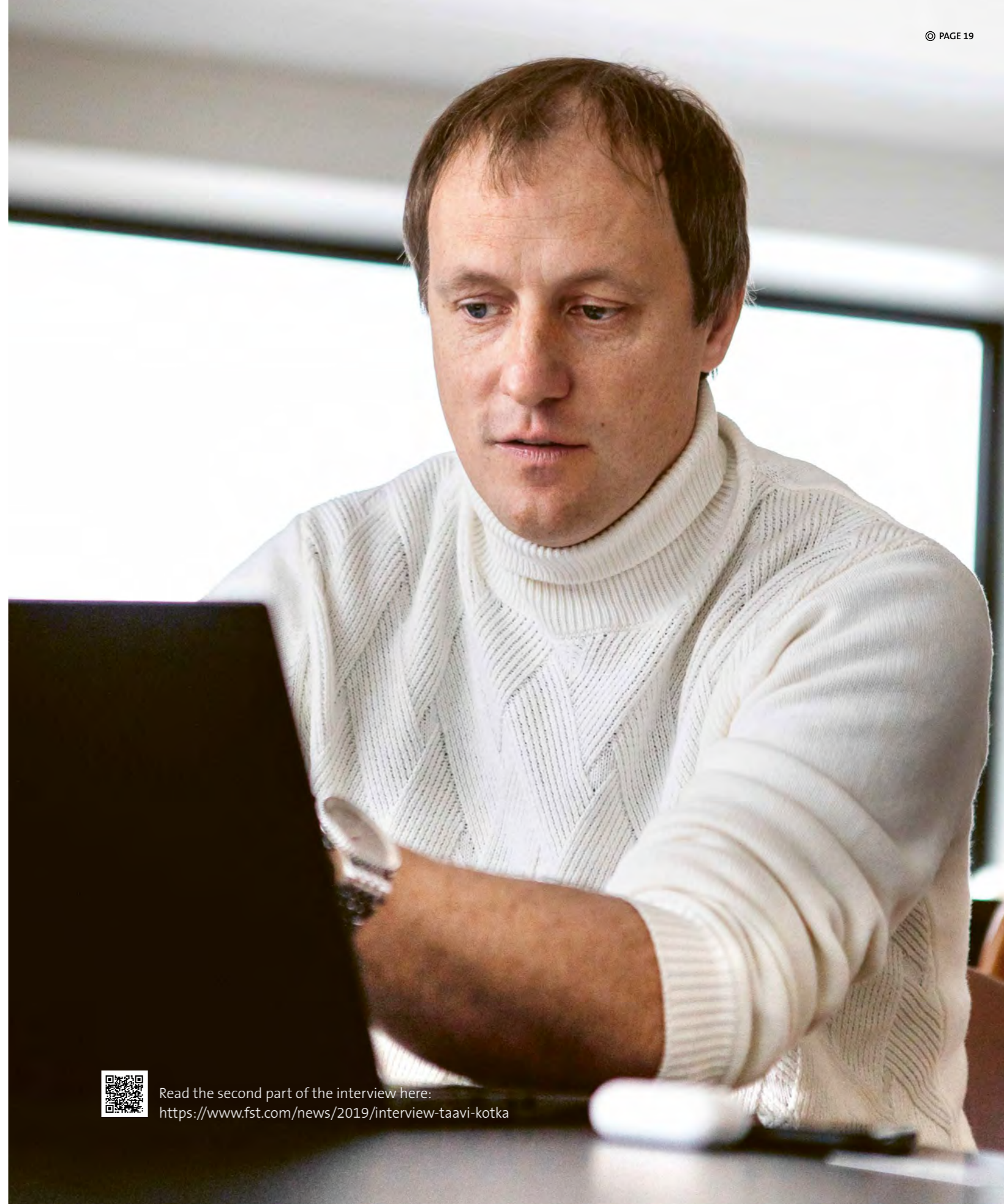
AND ASIA IS LEADING THE WAY?

My worries are that if China would say to the next generations in Europe you can open up your businesses in the Chinese market, you have full access to Alipay and other financial tools, you have a 1.3 billion market. It's all yours and please open your company here. Then it might end up like the CD and Spotify. You used to buy the CDs from the local store. Now, the store is no longer there, it's bankrupt because you are giving your money to Spotify. Or what if the Chinese health care system is able to give 20 more years of meaningfully lived life to every person in China? Maybe elderly Europeans will start to think they should use the Chinese health care system and give their data, samples and genomes to them. That might have huge implications for our health systems in Europe. Everything becomes a service in the future and digitalization is the door opener.

YOU ONCE SAID THAT THE PSYCHOLOGICAL STRAIN WAS NOT GREAT ENOUGH FOR LARGE COUNTRIES LIKE THE UK TO SYSTEMATICALLY EMBRACE DIGITALIZATION? WHY NOT?

The problem is uncertainty and fear. It's easy to say, "Oh, you know there's cybercrime." And, "Oh, privacy concerns, data protection concerns." Yes, they're right. But you can be digital and have your privacy protected. We just show that Estonia is more protected than the UK even though we're more digitalized. I think the real fear is that the people who influence the thinking of society, especially bureaucrats, are just afraid of losing their jobs. That is actually the main reason.

THANKS A LOT FOR THIS VERY INSIGHTFUL CONVERSATION. ©



Read the second part of the interview here:
<https://www.fst.com/news/2019/interview-taavi-kotka>



WHAT'S THE BUZZ?

So you want to make a good impression with your next presentation?

Your best bet is to throw a few buzzwords from the tech world into your talk. And it might be a good idea to know what they mean.

ON THE TRAIL OF TREASURE

BIG DATA

The more Lego bricks there are in a box, the harder it is to find the exact red double brick that you need for your next step. But from years of experience, you know with a high probability that this brick can be found hidden at the lower right – for whatever reason. These types of conclusions can be drawn with the aid of high-performance computers that analyze large quantities of data. This approach is known as Big Data. Most of the analyses look for correlations between various data sets. This is leading to surprising insights. For example, the fact that boys, on average, spend three times as much time playing with Legos as girls do. And that the preference for particular brick colors depends on whether the projects are built on a weekday or on the weekend. What's the value of such insights? For example, to evaluate the huge quantities of data – up to a gigabyte per minute – from a self-driving car and to learn from the information. But caution is in order: not every correlation is meaningful. For instance, it can be shown that people who eat a lot of ice cream face a greater risk of shark attacks. Of course, this has nothing to do with ice cream but rather with the fact that people often eat these frosty confections at the beach. ©




BASIC DEMOCRATIC DECISION-MAKING

BLOCKCHAIN

A land registry is incorruptible. Only those who are listed as owners can be said to own a plot of land. From a logical standpoint, the precondition for such a system to work is that there is only one, stringently safeguarded registry. That kind of security is hard to establish in online transactions. To be sure, every issuer of a credit card maintains accounts on all the transactions undertaken with it, but data thefts and misuse are not uncommon. That was the reason an anonymous software developer sketched out the first blockchain in 2008. The basic idea is simple: there is no central registry; all the computers operating within a network store transactions as a so-called block, which is attached to preceding blocks. If a new transaction is pending, it is sent to all the computers and checked for plausibility. It is only carried out when the majority in the network say: "That's okay by me." This basic democratic approach is considered to be extremely secure, but very laborious. That's why modified blockchain processes are being tested – to make charging electric cars easier, for example. ©





IOT

EACH WITH EVERYTHING

INTERNET OF THINGS

On paper, anyway, intelligence just keeps growing. We live in “smart” houses, drive off in “smart” cars and travel through “smart” cities. The term refers to an almost trivial interrelationship. Now that nearly all technical devices, from heating systems to traffic lights, are electronically regulated, it is possible to network systems over the mobile Internet as the next step. That means heating systems will know what the weather will be tomorrow, and traffic lights will know the number of vehicles backed up on the road before them. All of these entities, constantly computing and communicating without the aid of humans, form the Internet of Things. In 2012, Cisco, a producer of networking equipment, estimated that there would be 50 million network devices constantly online in 2020. It’s impossible to verify how accurate this figure is. The number – often cited without a source – continues to show up in countless PowerPoint presentations. It’s certain that the benefits arising from a communication network rise exponentially as the number of participants climbs, while costs only increase linearly. This law was discovered by the electrical engineer Robert Metcalfe in 1980 – exclusively with the help of human intelligence. ©

CALCULATING WITH MULTIPLE UNKNOWNNS

ARTIFICIAL INTELLIGENCE

It was the dream of a number of American scientists in the 1950 to create a machine whose capacities could not be distinguished from those of a human. Since then, “artificial intelligence,” or AI for short, has had a diverse career, and AI researchers today are much more pragmatic than they used to be. They simply take various technologies that go beyond the reach of classic information science and bundle them under the term AI. They assume that strictly defined actions follow certain inputs. But that doesn’t help you drive a taxi or translate a text correctly. That’s because the taxi driver and the translator operate in unknown territory where all the circumstances cannot be reliably defined ahead of time. The meaning of a situation or a sentence is developed on the basis of experience and context. With AI technologies like machine learning and neuronal networks, computers can be taught these capabilities. But, at least for now, it is clear that the programs will be highly specialized. The software used for translations can’t be retrained to drive a taxi if it were to ever become unemployed. ©



REVOLUTION FOLLOWS EVOLUTION

5G

Life is indeed good when the display on your device shows several bars behind the three letters “LTE,” indicating good reception. LTE stands for the mobile wireless standard “Long-Term Evolution,” otherwise known as fourth-generation technology or 4G. With a theoretical download speed of more than a gigabyte per second, it makes it possible to share videos with your best friend far from your home network. Many consumers simply cannot understand why 5G, the fifth generation of mobile wireless technology, is knocking at the door – wouldn’t it be better to have more transmission towers for the fourth generation? In fact, 5G provides much more than superfast speeds – ten times the download rate of its predecessor. For the most part, the next generation of mobile wireless technology is setting out to enable business applications that depend on minimal latency periods. In this sense, latency means “hesitation” – and it falls to less than a millisecond with 5G. The ability to transmit data at these speeds with absolute security is needed to warn autonomous cars about driving hazards, for example. In addition, in the factory of the future, 5G networks that are inaccessible to the public will handle part of the data management. ©





BUTTER AND BYTES

Spelt baker Stefan Dümig has three facilities near Munich. Is his company too small for automation and digitalization? On the contrary, Dümig says. He is constantly on the lookout for better equipment and more efficient processes, and he is now expanding his online business.



Spelt

Although it was widespread in Europe in earlier times, spelt was extensively replaced by wheat during the age of industrialization. Due to its husks, spelt is more robust than wheat, but requires longer processing. Some bakers, including Dümig, believe the processing offers some nutritional advantages, making spelt's enzymes and gluten less aggressive. Today spelt has regained some of its old popularity. Its main areas of cultivation are southern Germany, Switzerland, Belgium and Finland. Spelt only made it to the United States in 1890 and was later nearly entirely replaced by wheat, but the organic farm movement is slowly reviving it.

Stefan Dümig is standing in front of a large computer display and studying a list of ingredients in his storeroom, which smells of spices and fruit. The display on the scales only shows the color green for each ingredient when the correct weight in grams is attained. "Previously, bakers worked by intuition and experience," Dümig said. "Sometimes the intuition was right, sometimes it was wrong." In the worst case, the dough did not rise properly or the final product just didn't taste good. "I want precision," Dümig said.

Dümig's bakery is not a large operation. His grandfather made bread in the same building in Haar, near Munich. Its window shutters are yellow. It has a sales counter and a few roundtables where customers can enjoy breakfast in its front room. But its cellar is full of the kind of machines that you would normally find only in industrial bakeries – such as a large digitalized scale or a stirring device that automatically adheres to the correct kneading times. Even back in the 1990s, Dümig purchased a computer-controlled deep fryer that he could use to automatically turn over his doughnuts. "At the time, my colleagues laughed at me," he said. The machine did, in fact, make mistakes in the beginning; it cut the doughnuts in half when it turned them over. But Dümig was obstinate. Today, the fifth generation of the deep fryer helps him make 37 varieties of doughnut – everything from mango cheesecake to strawberry mascarpone.

Dümig, who has short, white-blond hair and the physique of a triathlete, seems to generate one idea a second. He continually imagines what he can improve or invent. His fanciful doughnut creations are joined by baguette-like loaves of white bread, so-called souls, in flavors like gorgonzola fig or spinach feta. Dümig adores his creations.

"People Often Bring Out an Idea Too Early"

He doesn't see his interest in computers and machines as a contradiction: "Quite the opposite. Thanks to the digital scale and the software in my office, I can devise new recipes more easily." If he is lucky, an attempt at a new creation will prove successful immediately. Dümig said he would prefer a direct interface connecting his office and the scale, then he could digitally schedule the orders for the next day. Screens showing videos of the bakery are mounted in the sales room, and the customers have WLAN. Dümig is also an active user of social media – he is developing his own app to let customers collect bonus points and pay with their smartphones. Even in 2019, many other German bakeries of comparable size don't even let customers pay by credit card.

CREATIVE

A "Black Soul" with cranberry and apricot. Baker Dümig keeps getting new ideas for recipes.

Perhaps Dümig owes his interest in experimentation to spelt. After he took over the bakery from his father in 1989, he quickly decided to bet on spelt flour. His ambition: to produce as many baked goods as possible from spelt instead of wheat. Spelt has to be processed differently, and there were hardly any recipes to guide him so he developed them himself.

Dümig likes to try things out. He was already experimenting with the “bio” concepts, which are widespread in Germany today, back when it was impossible to get bio-butter in parts of the country. Today there isn’t a single baker who doesn’t sell at least one bread variety made of ingredients from ecological agriculture. Dümig launched his first online shop eleven years ago, but closed it later. “People often come out with an idea too early, but they gain valuable experience,” he said.

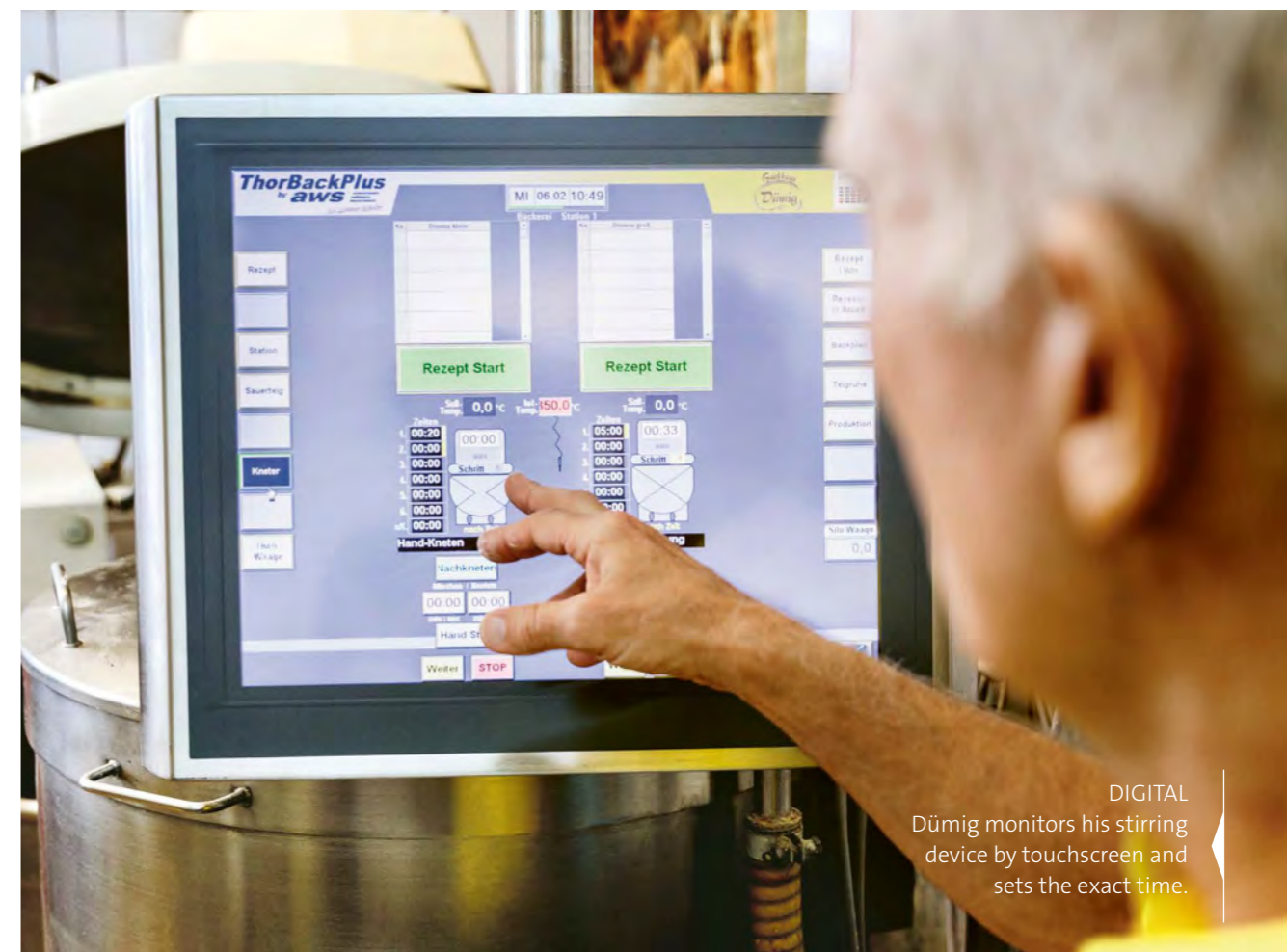
Increasing Quality, Avoiding Defects

Dümig is not just playing around. As the owner of the family business, he makes business-oriented calculations and recently opened his third operation. He has 55 employees. Despite his love for automation, the idea of unstaffed production facilities

doesn’t thrill him. “Machines are taking over the work that people dislike,” he said. “I would like to boost the quality of the craftsmanship and make fewer mistakes.” The goal: baked goods that are handcrafted and creative despite mechanical assistance.

Of course, new machines sometimes put stress on employees. In some cases, the equipment doesn’t run smoothly at first. The time and effort needed to run the new equipment suddenly turns out to be greater than the amount of work saved. That was the case with machinery that Dümig used to automatically produce soft baked goods such as baguettes. He spent 250,000 euros on the equipment. “I applied pressure to get it working, and the operators were peeved,” Dümig said. Today, they wouldn’t do without it. “It is precise and it conserves resources. And we don’t have leftover dough.”

The situation was similar for the automatic dough sheeter for puff pastries that Dümig has owned for 24 years. “No one with a bakery of the size has this,” he said. “It has really made a lot of money for me.” When the dough has to be folded 27 times,



DIGITAL
Dümig monitors his stirring device by touchscreen and sets the exact time.

AUTOMATION

Back in the early 1990s, Stefan Dümig had already started to look for useful equipment. “I want precision,” he says.



people get confused and count wrong, Dümig said. But the machine doesn’t. And his many baked creations were only invented after careful consideration from a business standpoint, he said. He noted, incidentally, that there is no bread with lemon grass and cellophane noodles. But it is worth trying, he said. “Even if the idea is too offbeat and doesn’t work, customers will at least try it once. They are curious and keep coming back. They enjoy being surprised,” Dümig said.

“It’s the Only Option”

Dümig is now busy with the third edition of his online shop. It proved to be a success this time. It is growing at a good pace, almost too good. He hasn’t even advertised it yet. It would be inconvenient if he were suddenly swamped with orders and he couldn’t deliver the products. He has worked on ways to send his baked goods throughout the country and have them still arrive fresh. “We bake some of them halfway and immediately package them hot to sterilize them.” The customers only have to re-bake them at home.

“THE MACHINES TAKE OVER THE WORK WE DISLIKE. DESPITE MECHANICAL HELP, BAKING IS CREATIVE – IT IS A CRAFT.”

“SOMETIMES I ASK MYSELF WHY SO MANY OF THE OTHERS AREN’T FOLLOWING SUIT. WE’RE SHOWING THAT THIS CAN WORK.”

Another of Dümig’s tactics involves the shipment of pretzels. He uses a special form of salt that moisture doesn’t dissolve. You get the sense that he leaves little to chance. Yet he is a little surprised by his success. It is clear that allergy sufferers or spelt lovers throughout Germany would use his online service. But why would customers in northern Germany buy small sweet pastries typical of the region from a baker in Munich? Dümig smiles: “A baker needs the kind of customer who drives past four of other bakeries to shop at your place.”

Is this a way for small operators to survive competition with major bakeries? “It’s the only option,” Dümig said. “You have to develop a brand. Find your niche, be innovative.” Dümig has no fear of famous names. He went through a year-long process to affirm his right to call a feta spinach pastry “Popeye,” winning a court case against a U.S. company that had secured the rights on a pro forma basis. Dümig doesn’t know why so few master bakers are embracing the future and looking at issues like digitalization as an opportunity. “Sometimes I ask myself why so many of the others aren’t following suit. We’re showing that this can work.”

Dümig’s workday ends around noon, then it’s bedtime before the cycle starts all over again in the evening. The baker’s life is grueling, and the hours long. It is increasingly hard to attract young talent to the profession. Dümig sees online commerce as a reasonable, long-term investment from this standpoint as well. “I’ve told my kids, ‘Someday, when you’re no longer interested in doing this, you can sell just online. Then you can sleep in until 7 a.m.’”

On the way from the automated stirring machine back to the office, Dümig says he would be happy to use a robot in the bakery. Unfortunately, the space is too limited for that. He moves past a cast-iron oven, a monster of a machine that is still wood-fired at great expense. “There’s nothing digital about this,” he says with a wink. A remnant of the past? “Oh no,” he says. “We use it for the *urlaub*, a bread made of natural sourdough.” It’s a nine-pound loaf made of rye and spelt. Dümig thinks for a moment and then says: “I didn’t know a better way to make it.” ©



“Bakery Die-off”

Germany, the land of bread. The typical German eats 163 pounds of bakery products in a year. The corresponding figures are 132 pounds in the UK and 92 in the United States. In Germany, however, the number of baking operations has dropped by 55,000 in the past sixty years. A total of 358 bakers closed down their operations just in the past year alone. But the German association of bakers rejects the idea of a “baker die-off” and talks about “structural change” instead. The trend is toward centralized production facilities with regional sales outlets. Currently, there are about 12,000 bakers. By comparison, there are 2,800 industrial bakeries and 6,000 bakery businesses in the United States.



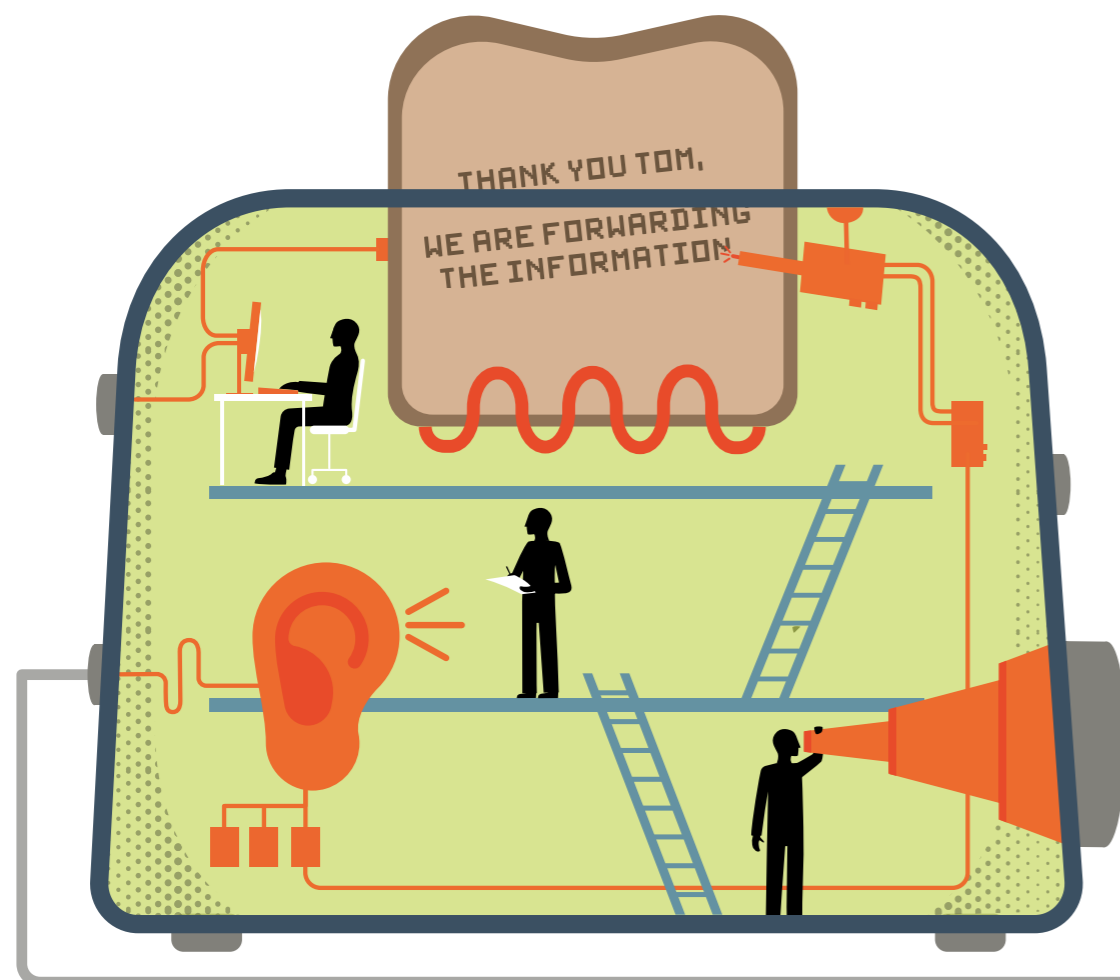
Our sealing solutions for the food and beverage industry can be found here:
<https://foodandbeverage.fst.com/>



THE BURGLAR CAME IN THROUGH THE TOASTER

The “Internet of Things” is opening up a world of new possibilities.

But not just for users – for intruders as well. Many people are not yet aware they will have to subject their household objects to a new kind of security check.



Burglars are lazy. It's rare for them to try to break in through a steel door. They would rather see whether the glass door on the terrace can be pried open. In short, they look for the chain's weakest link. After all, the effect is the same. In the end, they get inside the house. The same is true for cyberattacks. All the attackers need is a single weak point, and they are in the computer. But when we say computer, what exactly are we talking about?

(Almost) Everything Will Soon Be a Computer

In a growing number of households, a range of appliances already qualify as computers: vacuum cleaners, baby monitors, televisions and heating systems, to cite just a few examples. Toasters burn images sent from smartphones into slices of bread. Coffee makers tell the home network when the beverage is ready. Parents send voice messages to their children via their stuffed animals. This stuff already exists. An ever-increasing number of objects that we once would not have described as “information technology” now have online-capable computers inside them. Their uses range from sensible to dubious. They could just be examples of clever marketing.

No one knows exactly how many devices are capable of logging onto the “Internet of Things” (IoT), but the figure is presumed to be more than 7 billion. It could rise to 12 billion in 2020. Other estimates put the number at 20 billion. Could we soon have sensors in our tables and chairs? In all likelihood, yes.

The manufacturer of a cardiac pacemaker created a stir in 2017 when it asked patients to have a firmware update in-

stalled at their doctors' offices. Unauthorized persons could change the pace of the signal remotely using security gaps, it was reported. “We are well on the way to an era when physicians double as patch managers,” the online portal IT-Daily-net commented.

Comparatively speaking, you could argue that it is of little consequence whether the intruder penetrates the computer chip of an e-cigarette. But the world isn't that simple. Everyday IoT objects could become an open, unlocked window into the household network that a smart house or a home laptop employs.

An intruder could make his way into the cloud or the app that a device uses in much the same way. Then he could get data from it. The motives for data thefts are diverse – they may be financial or political. IoT devices can be used to ship illegal files via obscure pathways or bundled together for denial-of-service attacks. This will impair the performance of the devices.

No One Patches a \$2 Device

But why are IoT devices so susceptible to security gaps? “It is impossible to write perfect code,” author Steve McConnell wrote in “Code Complete.” Out of every thousand lines of code, there are more than five errors that open up entry points. And in a modern automobile, there are easily 150 million lines of computer code.

Security gaps can be closed afterwards with updates and patches. But no one patches a device that's only worth a couple dollars. Purchasers today need to perform their own due diligence before buying a device. Experts recommend

that users find out how frequently software updates are deployed. Or they can turn to so-called CVE sites and look up whether providers frequently appear there with their weak points. This is a way to identify vulnerable devices. But is it realistic? Who is willing to do that before buying a toaster on impulse?

Entirely Legal Security Lapses

So far, governments have been sparing in their support for their citizens as these challenges arise. Responding to a question, the German Interior Ministry told the Bavarian broadcasting service: “So far, IT product security is not a mandatory pre-condition for access to the market.” In other words, it is completely legal to sell IoT devices with security deficiencies in Germany. The same is true for other countries.

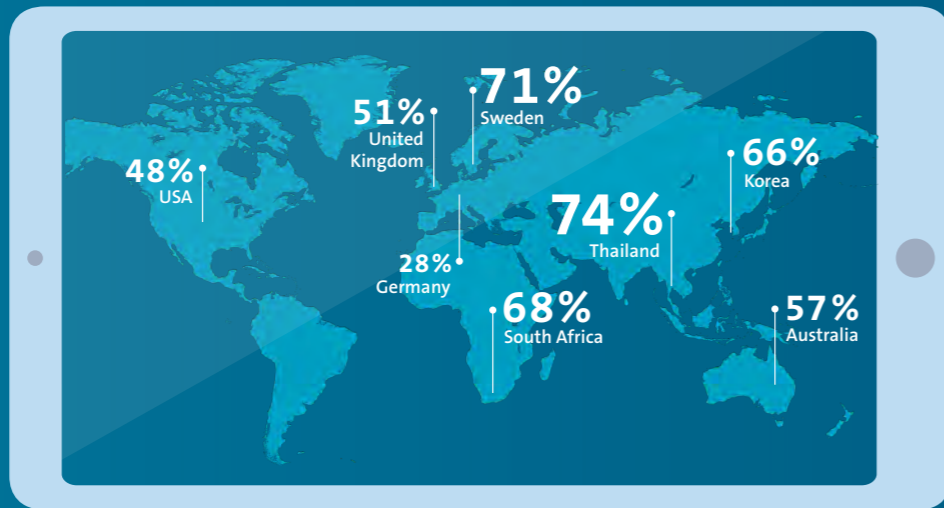
To make matters worse, many providers take the easy way out. For example, it is customary to mask the functions from the user so it might be possible to use them later, even though this makes it easier for intruders to activate them. Many manufacturers have their own interest in selling Internet-capable devices: they collect data on how customers deal with their products and obtain valuable information for their further development. And a growing number of devices are logging onto the Internet without the users' involvement or even their awareness.

So what about IT security checks before the purchase of our next vacuum cleaner? In our own interest, we should develop the skills to perform them. And occasionally question whether it make sense for our new high-pressure cleaner to actually go online on its own. ©

FACTS AND FIGURES DIGITAL MONEY

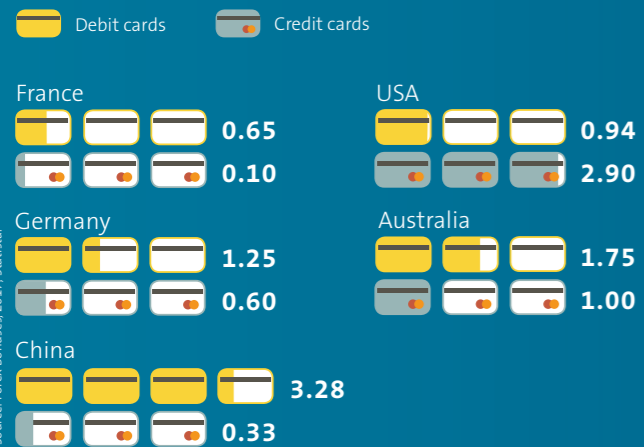
PROPORTION OF INTERNET USERS WHO USE MOBILE DEVICES FOR BANKING SERVICES

Mobile banking is widespread in many Asian countries, Northern Europe and South Africa. By contrast, Germans tend to use their PCs – or a bank counter.



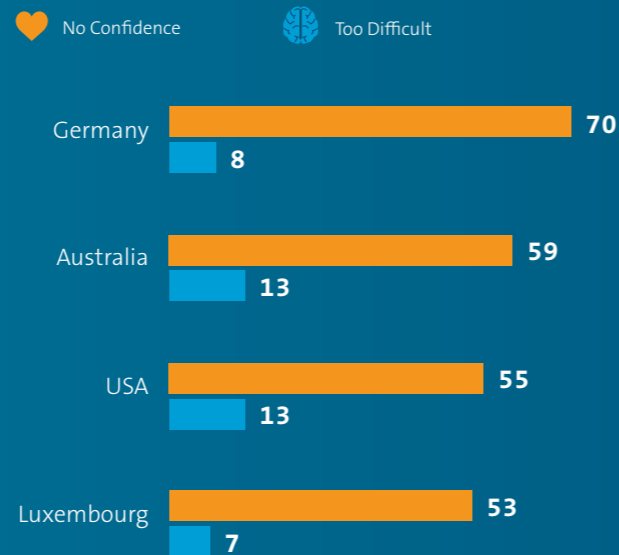
Source: We Are Social; Hootsuite; DataReportal (C) Statista 2019.

NUMBER OF CREDIT CARDS VS. DEBIT CARDS per capita



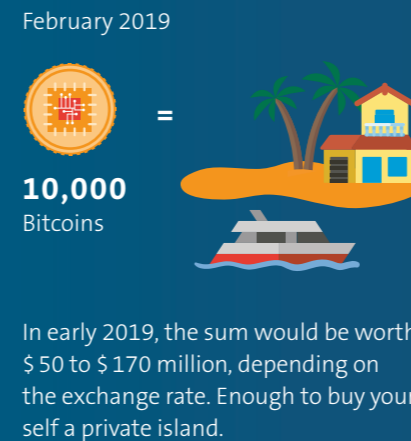
In China, three debit cards per person is the norm, and there are hardly any credit cards. The situation is the reverse in the United States. The French have been skeptical about credit and debit cards right down to the present. The typical Australian always has both in his wallet.

WHY THEY DON'T USE MOBILE BANKING as a percentage

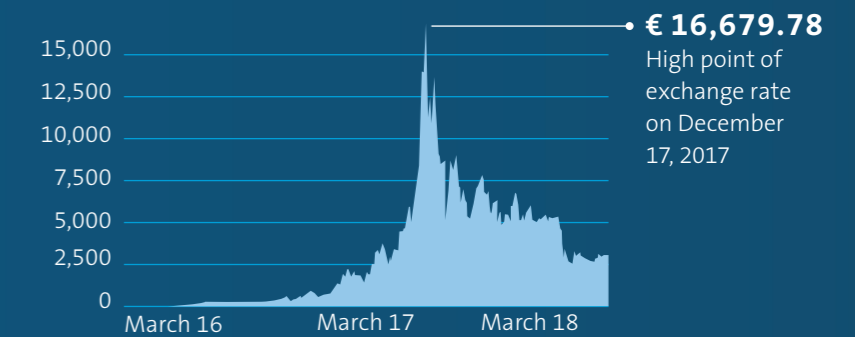
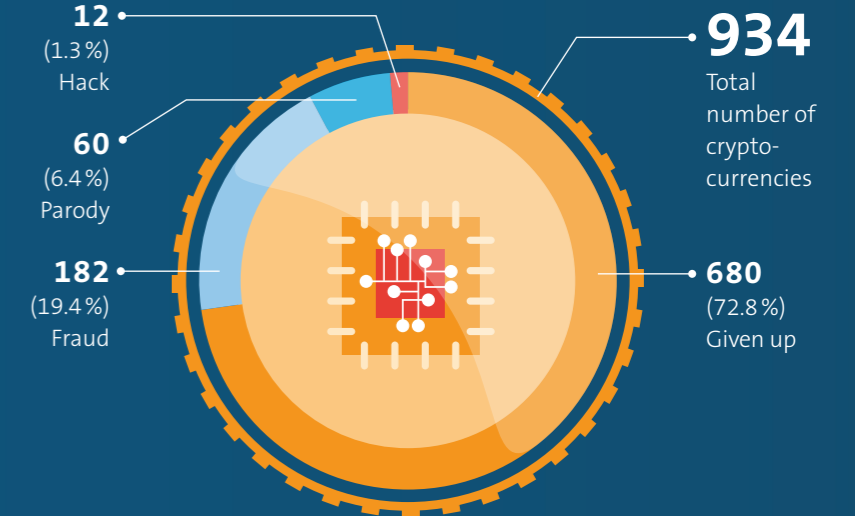


Source: Statista.

PIZZA WORTH MILLIONS

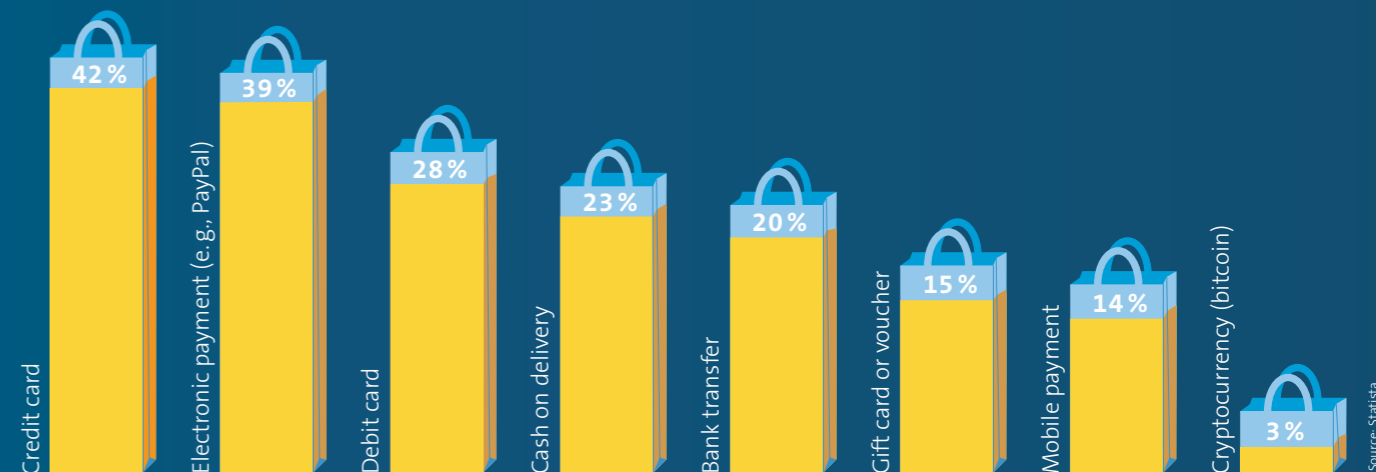


WHY DIGITAL CURRENCIES FAIL



While it is certainly far below its one-time high point, the exchange rate increase is still enormous compared to the early days of the cryptocurrency.

PREFERRED PAYMENT METHOD FOR ONLINE SHOPPING WORLDWIDE



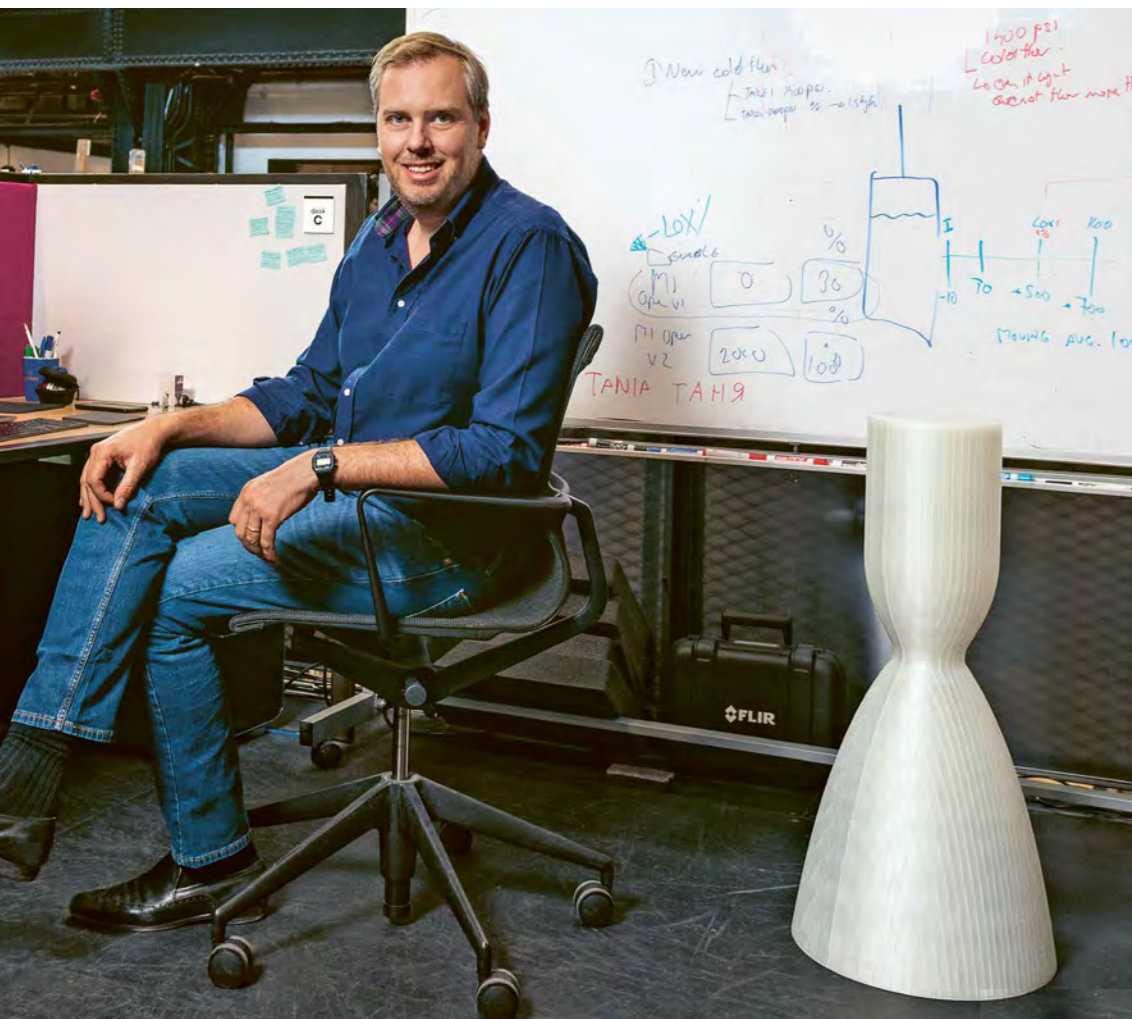
Source: Statista.



BACK TO THE FUTURE

America has always been the land of tinkerers. Now a technology center in Brooklyn is opening a new chapter: With the help of digitalization, startups are inventing concrete products that could change the world.





DESTINATION: ORBIT
Max Haot, founder of the rocket startup Launcher, with a nylon workpiece from his rocket engine.

IT GIVES ITS MEMBERS ACCESS TO A MIX OF EQUIPMENT THAT CAN PRODUCE BLANKS BASED ON DIGITAL TEMPLATES.

The pictures of the visionaries of space flight and rocket technology catch the eye: Wernher von Braun, Richard Branson and, of course, Elon Musk. A cylinder made of whitish transparent nylon that is tapered in the shape of a cone stands on the floor of the large loft – the first model of a rocket engine totally constructed with a 3D printer. In eight years, this type of engine is supposed to be able to shoot mini-satellites into space inexpensively. That’s the vision of Max Haot, founder of a company called Launcher. “Satellites are being shrunk from the size of buses to the size of a loaf of bread – this requires entirely different carrier rockets,” said said 41-year-old Haot. They could make it possible to launch a network of mini-satellites into orbit and provide Internet services worldwide. Launcher is one example of a large number of startups that have found the home they need at New Lab in New York. New Lab offers young companies a creative environment where they can use and share innovative production technologies, hands-on-advice and a community of like-minded thinkers. Their home is the Brooklyn Navy Yard, a decommissioned

shipyard of the U.S. Navy. Warships were built here during the Second World War. Now its huge manufacturing spaces are a playground for startups.

Huge Creative Center with Digitalized Production

New Lab spent nearly \$60 million on renovations for the industrial building two years ago. It is a partnership between private investors, New York City and the state of New York. “We wanted to revive the location of state-of-the-art manufacturing of the past century in a fitting way,” New Lab founder Scott Cohen said. He and cofounder David Belt visited top universities such as MIT and Stanford to assess the status quo of the most advanced production technologies today. Digital processes play a main role here. New Lab is more than just a huge creative center for startups in a cool location: “We are in the business of supporting entrepreneurs, growing companies,” Cohen said. It gives its members access to a mix of equipment – 3D printers, laser cutters and CNC milling machines – that can produce blanks based on digital templates. Leading companies in additive and subtractive production processes, such as the German firm EOS, Southwest Industries, and Hass Machinery, have made their most sophisticated equipment available to New Lab. This allows the transformation of new ideas into prototypes quickly and cost-effectively on site. They can be presented and enhanced immediately.

“Products that Solve the Problems of the Future”

Over the past few decades, the largest share of software innovations has come from the United States. Breakthroughs in hardware are considered more complicated, but they are exactly at the heart in Brooklyn. Since much of its production capacity has been moved to less expensive foreign countries, America has lost some of its manufacturing expertise. But the United States is still a country with a great many mechanical and automotive engineers as well as tinkerers. New Lab offers the founders of hardware companies a nurturing environment. “Here we are involved with tangible products that solve the problems of the future,” Cohen said. “We expect a manufacturing renaissance.” But it will have little to do with the billowing factory smokestacks and the piecemeal labor of the Industrial Revolution. “The perception of fabrication and how we interact with the physical world is changing,” he said. “In our times, digitalization of manufacturing is central. Mass customization is possible. The trend around Lot-size One that we see in apparel and sport shoes will extend to all kinds of products.”



SCOTT COHEN
New Lab founder

Rocket Engines from a Printer

Launcher is one of more than 100 companies – which employ more than 600 workers in all – that want to change the world from their base in New Lab. Taken together, these startups have attracted risk capital of more than \$250 million. The process of choosing interested companies is highly selective: New Lab only accepts 15 percent of all applicants. New Lab has even taken an equity stake in 14 of them. Launcher founder Haot is inspired by the Soviet Union’s rocket engines, designed in the 1980s, which reached the highest performance ever and are still in use. “Our goal is to bring this proven high-performance technology to the USA and use 3D printing to reduce its cost by a factor of 10.” In these engines, cold liquid jet fuel flows through a complicated geometric system of channels in the metal of the combustion chamber. This cools the engine and keeps it from melting at high temperatures. It is expensive to mill the channels in the metal – but the process is affordable if it is done additively. Haot managed to attract an expert with 35 years of experience from the Ukraine to New York. Together they printed their first small prototype made of plastic. Haot then used New Lab’s contacts with EOS in Germany to print the combustion chamber out of metal. To realize his vision, Haot, a native of Belgium, became an American citizen so he could work on rockets in the United States.

ON A SPACE MISSION

Honeybee engineer Yoni Saltzman develops custom-made products for NASA, such as a device that can collect sediment on other planets.



Digitalization Is Expected to Contribute to Space Missions' Success

During the summer of 2016, Honeybee was one of the very first members of New Lab. The company produces special orders for NASA and other clients. At 35 years old, Honeybee hardly qualifies as a startup, but it works on very sophisticated technical ideas. "New Lab with its advanced prototyping equipment is ideal, because small and medium-sized companies often can't afford these expensive machines," said Honeybee engineer Yoni Saltzman, who is now working on a project for NASA's Langley Research Center on In-Space Assembly. "We are creating a strut assembly system for a truss structure that robots can put together in space," he said. The idea is to assemble the individual pieces together with a click like a child's toy. Robots could later use the system to construct buildings in space. Honeybee prints the many prototypes for the click system on 3D printers. Later, in a special workshop, they are supposed to be milled from metals suited for use in outer space. Digitalization is revolutionizing Saltzman's work. "At New Lab, we design faster and more flexibly, because we can create and modify prototypes at little cost."

MOTORCYCLE WITHOUT THE RUMBLE
The body of this electric motorcycle by Taras Kravtchouk is totally produced with a 3D printer. It heads into series production this year.



PRINT IT!
This small robot from a 3D printer can inspect tubes from the inside.

Freedom for Manufacturers and Customers

Taras Kravtchouk, 34, is thrilled as well. He printed the prototypes for his electric motorcycle, Tarform, completely using 3D. He simultaneously experimented with various materials, including biodegradable plastic. Kravtchouk, a Swedish product designer who came to the United States eight years ago, collects old motorcycles. "What Elon Musk showed with Tesla is that electric cars can be beautiful, and that inspired me to create an electrical motorbike. The traditional brands did not show much initiative," he said. Kravtchouk equipped his motorcycles with sensors that, for instance, warn riders if a car is threatening to cut them off. "Biking is all about the experience of the ride and being in control of the vehicle – autonomous driving would be wrong. We bring more security without compromising the rider's sense of freedom," he said. This year, Kravtchouk plans to 3D print various external parts at their own facility close to New Lab. "Additive technologies are already more capable of producing just prototypes," he said. "Today, we already can utilize additive manufacturing during our low volume production of the first 100 vehicles – and each one can be customized." Everything is indeed looking up for New Lab and its members. ©

KRAVTCHOUK EQUIPPED HIS MOTORCYCLES WITH SENSORS THAT WARN RIDERS.

CREATIVE TESTING
The New Lab has numerous 3D printers.
Its range of printed objects emerged from
a pure passion for creativity.





THE ALLURE OF THE ANALOG

Digitalization is penetrating all areas of life, but analog countertrends have recently become the talk of the town. We take a look at a few examples.

STREAMING VS. LPS

State of the Art

“Digital Is Better” was the name of the debut album of a German indie rock band in 1995. The statement could well apply to changes in the consumption of music. CDs were hip back then. In 2000, 2.4 billion of them were sold worldwide – an all-time high. By 2015, the number had fallen to 569 million. Today, consumers are increasingly downloading or streaming music. Thanks to mobile end-devices, music can be bought, managed and retrieved in no time at all. A personal mix of hits is just a click away, anytime and anywhere.

Countertrend

Thirty years ago, records were on the road to extinction, but they have actually fought their way back. These days, record companies occasionally press as many vinyl records in a single day as in an entire month twenty years ago. While 6 million records were sold in the United States, the United Kingdom, and Germany in 2012, the figure rose to 22 million in 2017.

The Drop-outs

One-third of the record buyers are millennials who largely grew up without LPs. The BBC has spoken with some of them. Twenty-one-year-old Jake from Londonderry said he only collects records because he finds their sound so enriching and much better. He no longer downloads his music. ©



SHORT MESSAGES VS. CARDS

State of the Art

It has never been easier, quicker or less expensive to convey greetings or congratulations on special occasions. Just send a message via a short messaging service or email, and the addressee will receive it instantly, complete with snapshots, on a smartphone or PC.

Countertrend

Why not send something more durable? In 2018, half of all German tourists – and even more than one-third of all young adults – sent postcards while they were on vacation. The greater effort associated with postcards is more appreciated than just another fleeting text message. Cards will also commemorate an event longer than electronic messages.

The Appreciator

Sheldon Yellen doesn't think much of electronically conveyed congratulations. The CEO of BELFOR Holdings Inc. in Michigan writes out the birthday cards for each of his employees by hand. That works out to 8,000 cards a year. He believes the effort is worthwhile. The handwritten cards make it much easier for him to have conversations with his employees and they feel highly valued. And he knows they appreciate his gesture. ©



SOFTWARE VS. NOTECARDS EVERYWHERE

State of the Art

Today, companies of every size and every industry are organized digitally. Quotes, orders, invoices and employee management are handled by computer, so coordination is straightforward using the appropriate company software. The software's task is to deal with projects and employees systematically.

Countertrend

To get the big picture, companies are again turning to long-disdained notecard systems. Toyota came up with the kanban principle seventy years ago to increase its productivity. What worked then still works today. Even software teams like to use it. The status of a number of projects can be quickly scanned and potential improvements identified.

The Seers

In 2015, the infrastructure department of Porsche Informatik in Austria chose a kanban process as a flexible way to improve the organization of its labor. Two years later, employees were still using their kanban board with its many bits of paper, and they were getting outstanding results – even if the pieces of paper had a barcode on them in the meantime so that progress could also be documented digitally. The system itself was still analog. ©



UNSTOPPABLE

Artificial intelligence is revolutionizing software development in the auto industry, which largely thinks in terms of if-then relationships.

The new algorithms are not just being used for highly automated driving – they're expected to solve nearly any problem that classic control engineering is unable to handle.

d=25'
Light = "red"
σ/√n

d=9' 6"
σ=.5"

d=9' 10"
σ=.6"



A solid line could easily have thwarted Daimler's grand spectacle. A few years ago, when Daimler engineers equipped an S-Class so it could retrace Bertha Benz's historic ride automatically, the project largely went well. The vehicle moved cautiously through Ladenburg's city traffic and didn't drive too closely to other vehicles out on the highway. It was only when a delivery vehicle blocked the lane that the rolling supercomputer became an obstacle to traffic. Then it adhered strictly to the traffic rules envisioned by its creators, which stipulated that a continuous line must not be crossed. At that point, if not earlier, it must have been clear that autonomous driving would never work in an urban environment if you stick with classic control technologies. It is simply impossible to program a machine to be prepared for any possible circumstance or hazard during city driving. This requires software that solves rule-related conflicts based on experience. The required algorithms are artificial neuronal networks that are trained with machine learning.

The use of artificial intelligence for highly automated driving starts with the unequivocal recognition of what the sensory "eyes" of the car see. Machines must take pains to learn something that comes naturally to small children. Deeply layered neuronal networks provide the key to computer-supported image recognition. They rely on a multilayered system based on the smallest possible computing units, the so-called neurons. Each neuron passes its findings on to the neurons in the underlying layer, and the rules governing the way they are calculated and forwarded change continuously. Neuronal networks really can't do anything at first – they have to be trained. They can only differentiate a dog from a cat once they have seen images of many breeds of dogs, but the process can be extensively automated by feeding the machine images and the associated image descriptions from a photo database, for example. The more layers that a neuronal network has, the more complex the learning processes, which make all this possible. That is where the much-used phrase "deep learning" comes from.

With AI, machine systems could soon take over control temporarily, even if only on certain stretches of road, the so-called operational design domains, or ODDs. They are a specific type of road in a clearly delineated geographic region. For example, BMW plans to start testing its own fleet at speeds up to 70 km/h (43 mph) in an urban environment in 2021. The

automaker's future partner, Daimler, has announced similar tests. At that point, at the very latest, AI computers will be in vehicles for the first time. They rely on high-performance chips that have their origins in the world of computer games. Their graphic processors are capable of carrying out a great many computing operations in parallel, making them perfect for neuronal networks where computing processes take place in many small steps.

BILLIONS IN SAVINGS POSSIBLE

Artificial intelligence is coming into use in many other areas of the auto industry, according to Patrick van der Smagt, who leads a research group at the Volkswagen Data Lab in Munich. "Artificial intelligence is not just of interest for autonomous driving, but also for many facets of our company, whether in production or replacement parts supply." As an example, he cited an internal contract for software for an electric racing vehicle. It forecasts when the battery will be completely discharged. "It is important to have completely used up the energy contained in the battery at the end of the race, without coming to a stop prematurely," he said. "This cannot be solved with classic control technologies."

The Porsche Data Lab in Berlin is working on another application. Claudio Weck is pursuing this approach that the sound of a system often reveals more about its technical condition than its outer appearance. If you train an AI system specializing in pattern recognition with typical sound images, it can recognize deviations and trigger an alarm. "Every technical system has its own acoustical fingerprint," Weck said. "Deviations are almost always indications of a distinct change in the system's behavior."

Whether the field is predictive maintenance or production control, whether it is automated translation of training material or financial controlling of marketing measures, there is hardly an area in the auto industry where AI cannot be used. Just in the manufacturing process, according to a McKinsey study, up to \$ 61 billion can be saved industrywide with AI. One example is automated quality control. This raises employees' fears. But so far there has not been a single instance of a dismissal due to the introduction of an AI system. There are still a great many solid lines to cross on the road to autonomous systems. ©



©
 THINK BIG!

UPHEAVAL
 Huge masses of earth and stone have been displaced in Guizhou for Big Data Centers.

If data is truly the oil of the 21st century, then, in a figurative sense, the Chinese province of Guizhou will soon have one of the world's largest oil reserves.

What's going on there? And what is the master plan behind it?

The province of Guizhou is three hours' flight southwest of Beijing, and both the province and the central government have big plans for it. A Big Data center for the second largest economy in the world is being built in a region that is still one of the poorest and least developed areas of China. But from now on, the digital heart of China is expected to beat in Guizhou, which has been shaped by tourism and coal mining so far. Driven by Internet companies such as Alibaba, Baidu and Tencent, China has become a digital heavyweight in record time. The country accounts for more than 40 percent of the world's online commerce, and Big Data is supposed to be the key to restructuring the entire economy. In 2018, Xi Jinping, China's

head of state, emphatically declared the importance of Big Data to the country. It makes it possible to analyze huge quantities of data and define their relationships with algorithms. The goal to derive the maximum benefit from the information.

A 'Who's Who' in a Special Zone

The government has made major investments in Guizhou. Since 2015, the province has had the status of a Big Data special zone. This has included infrastructure improvements such as the construction of highways and freeways. Huge tunnels bored into the hilly landscape are the centerpiece. They provide space for millions of servers. Computing centers for the largest international

and Chinese IT companies have been built there or are in the planning stage. Huawei alone is making room for 600,000 servers. Tencent's computing center, which runs the WeChat message service, is expected to cover 30,000 square meters underground. Alibaba, China Mobile, China Telecom and Microsoft are following their lead. Apple, one of the world's most valuable companies, is also pitching its tent in Guizhou. The media are reporting USD 1 billion in investments.

Factors in Guizhou's Favor

Why is Guizhou of all places becoming the world's largest data warehouse? This swath of land offers many advantages. The low-cost energy for these

operations comes from local hydro-power. At an elevation of 1,000 meters, the mild climate helps to cool the server farms naturally, and it helps that they are housed in deep tunnels. They also offer protection against attacks by terrorists or aircraft. Another key factor is that Guizhou is not earthquake-prone. Its status could also help to counter the population's flight from the countryside. There are already some positive signs in this regard.

Enormous Upswings

In 2016, Alibaba reported that Guizhou was attracting more and more Chinese university graduates. During the year of the report's publication, the province already ranked seventh nationwide. In addition, U.S. companies such as Apple, Qualcomm and Intel have become involved with schools in the province, as have American universities like Stanford and the University of California-Berkeley. Big Data is offering job opportunities to less educated Chinese as well. It allows them to process still unstructured

data on PCs as they handle highly demanding routine work. In any case, the focus is fueling the growth of the IT sector in Guizhou. At the end of 2013, there were just 1,000 companies that dealt with Big Data, the Internet and online business there. But that number has jumped nearly tenfold in four and a half years. Guizhou is scoring points for its rapid growth, and Big data accounts for 20 percent of it.

Efficiency Driver

The government is fueling this upswing. Startups get space at a low cost or free of charge; later the rent is geared to the growth of the business. Public agencies cooperate closely with innovative firms. They pass on data that the startups use to develop business ideas, and the companies use those ideas to help the government. The economy is also expected to benefit. In 2018, Beijing launched a broad-based initiative designed to improve the performance of 10,000 conventional companies in the next five years with Big Data's help.

This is expected to be a USD 120 billion market, and the government can already point to the first successes. Liquor producer Moutai put Big Data to use in its supplier's logistics system and transaction platform, improving both sales and service. Similar outcomes are on the way in farming and manufacturing.

Rising Star

A young Internet startup based in Guizhou is already getting international attention. Manbang, also known as Full Truck Alliance, is considered to be the Uber of the truck sector. It improves hauling capacity utilization with an app that brings shippers and truck drivers together. The shippers save time and the truck drivers avoid empty loads. A full 80 percent of all the trucks registered in China have signed up for the app. More success stories are expected. Guizhou has displaced huge masses of earth and stone to create the world's largest data storage site, and they are now a harbinger of a Chinese economic revolution to come. ©



INNOVATION BETWEEN THE HIGH RACKS

INCOMING AND OUTGOING PACKAGES

Relatively small packages are received here or packed for shipment.

COMPLEX SHELVING SYSTEMS

Individual cartons are stored manually here. Advanced data glasses facilitate picking.

NEIGHBORING WAREHOUSE

PALLET PACKAGING

Complete pallets are packaged here and dispatched on their travels.

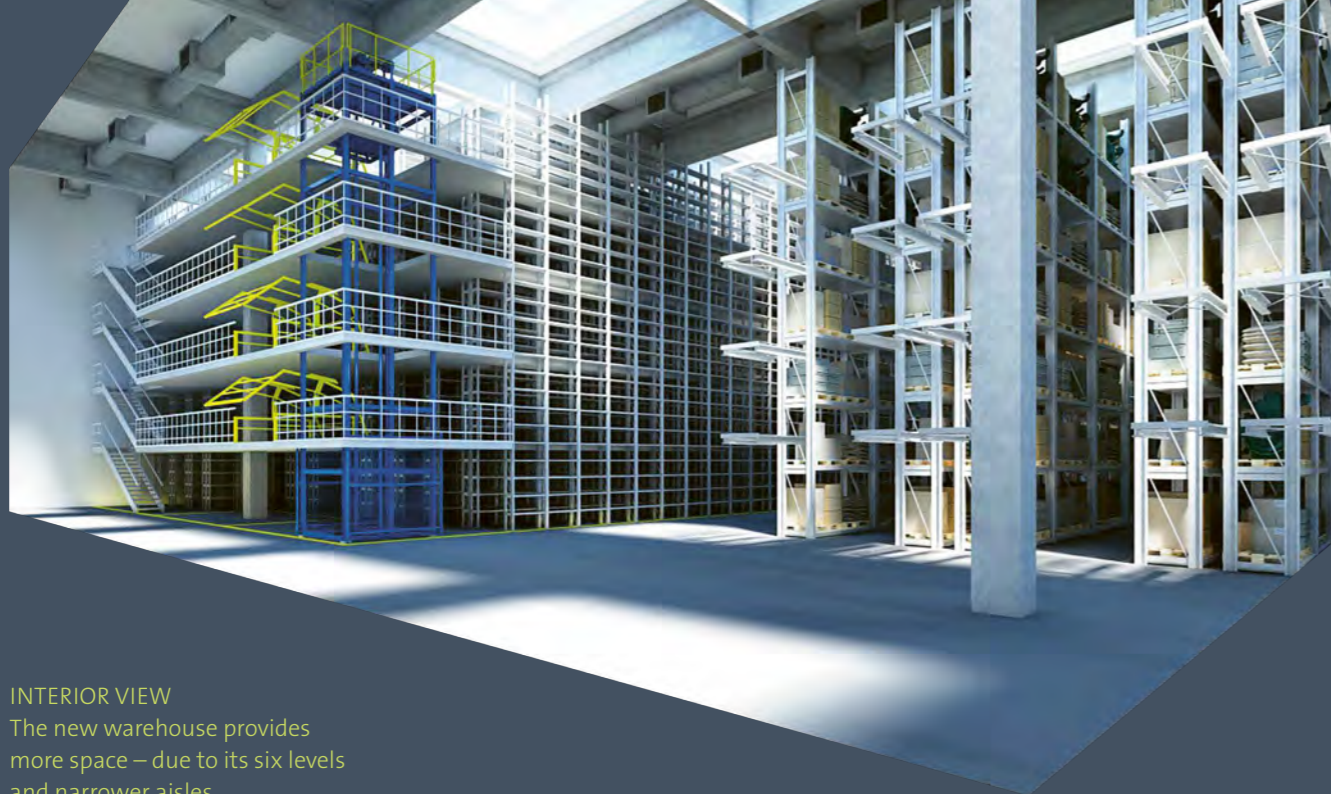
HIGH-RACK WAREHOUSE

Fully automatic forklifts operate in the narrow aisles of this warehouse.

Freudenberg Sealing Technologies (FST) is moving into a new warehouse in Bischofsheim over the summer. The facility is not only remarkable because it combines a range of advanced elements – it represents the future of logistics in multiple ways as well. The highly dynamic logistics sector is experimenting with automation and networking.

The red forklift steers resolutely and calmly toward a rack. It then extends its long mast, reaches into a shelf at a height of 23 feet, and deposits a pallet there. The fork pulls back, and the vehicle begins moving again. But the cab is empty – there is no one at the wheel. The forklift is fully automatic, orients itself spatially with the help of sensors, and receives reports via an online connection identifying the space to access. That will be the process at the new Freudenberg Sealing Technologies warehouse in Bischofsheim in just a few weeks. Automation is a major global trend, especially in warehouses. The advantages are clear. Aside from offering great flexibility, autonomous vehicles run flawlessly and conserve materials. Automated conveyors are also an up-and-coming technology, but the belt systems are anchored to one location. By contrast, forklifts can be programmed to follow a new route at any time.

Designed for narrow aisles, the forklifts at Bischofsheim seem both massive and lean. The vehicles can raise their black extension mast several meters into the air, yet their body is comparatively narrow. There is a good reason for Freudenberg Sealing Technologies to choose this type of equipment. An autonomous forklift will take up just one-third of the width of an aisle in the previous warehouse, making it possible to design narrower aisles for a new warehouse. And with a total of six shelf levels, this means much more storage space. The new facility, which will begin operating at midyear, has a total of 135,000 square feet of space, which is nearly the size of three football fields. “The self-driving forklifts are not the only innovative elements of the facility,” said Nadine Riehm, FST’s Director of Supply Chain Execution Europe. There are also autonomous pallet trucks – small, agile devices that can bring pallets to packaging stations, among other tasks – along with



INTERIOR VIEW

The new warehouse provides more space – due to its six levels and narrower aisles.

advanced logistics features such as a “pick-by-vision” system. With “pick-by-vision,” employees use data glasses to identify the items that they should pick next. As with automated vehicles, the benefit is a much-reduced error rate. “The entire process in the warehouse is IT-controlled and paperless,” said Sören Schmitz, FST’s Vice President of Global Supply Chain Management.

Autonomous vehicles, networked data and human-machine collaboration, the Freudenberg Sealing Technologies warehouse is a prime example of the innovations taking hold in the logistics sector – where things are really starting to move. Logistics experts are discovering hidden potential as various trends, including automation, networking and artificial intelligence, come together. These trends all pay off with more efficient warehousing, ensuring that goods, materials and replacement parts are stored and retrieved more intelligently and reliably. Throughput is also faster.

“It has never been as cool to work in supply chain management as it is today,” executives of large international companies say. “Don’t be afraid of intelligent machines – work with them!” chess champion Garry Kasparov was recently quoted as saying at an intralogistics conference. What is striking about the current trend is that the interest in intralogistics runs through every industry. Whether the companies are manufacturers,

retail chains or shipping firms, they are all experimenting with new technologies, ranging from palletizing robots to drones flying through warehouses. Classic manufacturing companies admit privately that they fear competition from new fields, such as software firms that have crucial expertise in networking and artificial intelligence. Especially in southeast Europe and Asia, relatively small producers of automated warehouse and manufacturing vehicles are springing up. Major companies in the intralogistics sector are countering them with broad-based sales and service networks.

Existing plants and warehouses occasionally give headaches to people hoping to transform them. The facilities have been built up over time and may be hard to automate due to their complex interiors. On the other hand, there is an advantage in integrating automation during the construction of a new warehouse.

The Freudenberg Sealing Technologies warehouse is symbolic of all these trends. The former warehouse in Lorsch had pushed up against its limits – FST even had to lease space across the street from its facility, which complicated processes and material flows. “We want to take advantage of opportunities to increase efficiency and move to a modern warehouse management system,” Schmitz said. FST’s new warehouse has made this possible. ©



PROF. MICHAEL TEN HOMPEL

Chair of the Materials Handling and Warehousing faculty at the Technical University of Dortmund and Institute Director at Fraunhofer IML.

LOGISTICS WAS LONG CONSIDERED AN UGLY DUCKLING. YOU ARE PREDICTING A PARADIGM SHIFT.

Ten Hompel: Today, production has to do with global process chains. Virtually the entire value chain is linked to logistics. Even a T-shirt needs a global supply chain. I think it’s time for logistics to take the lead here. For example, that would mean producing when articles or raw materials are available, which from today’s point of view would be a complete reversal indeed.

AND DIGITALIZATION IS THE REASON FOR THIS?

In any case, the effect is intensified by the fact that the loading aids are becoming intelligent. This opens up completely new possibilities – autonomous pallets, for example. The question is how such systems will organize themselves. We believe more and more that it is reasonable to take nature as an example – and nature doesn’t use a central computer. Efficient systems of nature are highly decentralized; millions of living beings are organized in swarms. With the digitalization of everything and artificial intelligence in everything, environments are created that are not unlike a swarm.

HOW CAN THIS BE CARRIED OVER TO WAREHOUSES WORK?

That’s the exciting question. Nature doesn’t build cars, but we want to build cars. So a swarm can organize itself, but it can’t necessarily act purposefully. That’s where technology comes in. In the future, artificial intelligence will be everywhere, and a sensor on every shelf will detect whether the right person is picking up the right things. And everything will network with each other in real time. The technology for all this is already available.

SO, WE COMBINE THE ADVANTAGES OF NATURE AND TECHNOLOGY?

The difference to nature is that we can control things via virtual channels. Every pallet, every container is connected via platforms. Think about it: In nature, everyone communicates at

300 bits per second, so to speak, when we technically convert the speed of our language. AI can communicate at millions of bits per second. This is a completely new world. That is disruption.

BUT EVERYONE IS TALKING ABOUT THE FACT THAT THE CURRENT DIGITALIZATION IS A DISRUPTION.

I would say that no one has really grasped the dimensions of disruption. People don’t understand exponential developments, and technical developments are usually exponential. At the turn of the millennium, a smartphone that is commercially available today would still have been considered a super-computer. For the first time in the history of mankind, we are in a situation where we have more technical possibilities in our hands than we can meaningfully use.

AND NOW WE ONLY NEED THE SOLUTION THAT WE USE MOST SENSIBLY?

Yes, digitalization is the key trend, but also the biggest challenge. And the consequences extend far beyond industry, even to moral issues. What about machine responsibility, for example?

ISN’T THE TERM A CONTRADICTION IN ITSELF?

Yes, indeed, because only a person can actually assume responsibility. It is precisely this contradiction that we must resolve: The machines start to learn and change their behavior. What responsibility do we want to assume in the future, how do we organize the interaction between man and machine? According to which standards should the machines act? The answer is probably different in China than in Germany. Let’s assume that the robot recognizes that a human being interacts incorrectly: How should it react? Engineers also have to face up to these challenges: If I build an intelligent machine for a warehouse, it will be capable of learning. The responsibility for how I program it then lies with me. But one thing is clear: there will be nothing more that comes without built-in intelligence. ©



ALWAYS IN THE AIR

Maximum safety for passengers with operating and service costs as low as possible – engine manufacturers such as Rolls-Royce are betting on digitalization to achieve this balancing act. A new generation of turbine engines is even expected to talk with the pilot.

It has been spitting fire for 800,000 years, but most Europeans, like many other people in the world, were unaware of Eyjafjallajökull's existence until the spring of 2010. That was when the volcano's eruption in southern Iceland led to a nearly complete interruption of transatlantic air traffic for about two weeks. The ash cloud from the eruption floated for some time over Europe. It was clear to experts that aircraft engines could aspirate the particles, which clumped together due to the heat, causing engines to malfunction. Aviation experts have been debating how realistic that scenario is down to the present. One reason for the dissent: it was hard to determine what and where the particles would be – and when they would be there. Only a handful of measuring stations in Europe were capable of analyzing the cloud's composition from the ground, and a single in-flight measurement by the German Aerospace Center (DLR) only provided a snapshot.

Volcanic ash might not be a problem for future generations of aircraft engines. Not because they are designed to be much more robust than current engines, but because they will self-monitor their condition at all times. The first smart engines are due to go into operation between now and the end of the year. They are units of the Pearl 15 model, a new power plant designed for business aircraft. They will provide well-heeled top executives with the opportunity to travel

nonstop from London to Hong Kong in luxury. The engine's hardware is an assembly of top technology. All the components of the compressor as well as high-pressure and low-pressure turbines are designed to operate at higher temperatures and pressures to boost efficiency and cut fuel consumption. In part, the use of titanium, new nickel-based alloys, and ceramic coatings make this possible. Their engine health monitoring systems are especially revolutionary. They observe the state of the engine on an ongoing basis even during flight. Richard Goodhead, who is in charge of marketing Rolls-Royce's civil aviation engines, considers this a key success factor. "Every hour that the airplane is in the air pays off for the operator," he explains. Today, even with business aircraft, it is less and less common for operators to be well-off private individuals or companies. Instead, they are likely to be specialized service providers operating fleets, with several dozen aircraft in some cases.

AVAILABILITY PAYS OFF

Since the 1990s, digitalization has become more important for aircraft engine maintenance. For example, Rolls-Royce operates a so-called availability center for business aircraft at its Dahlewitz site south of Berlin. It has a control room with a

INTELLIGENCE ON BOARD
Rolls-Royce engines for
Bombardier business aircraft.

large screen that shows the precise geographic position of all of the planes whose owners have maintenance agreements with the company. A few planes are shown in red; they are the ones whose flights are threatened with cancellation due to unexpected defects. Any canceled flights, of course, would result in severe economic consequences. For the most part, there aren't any planes shown in red. If there are, they are aircraft that face possible flight cancellations due to unforeseen malfunctions. Serious financial costs loom.

Axel Voege, Manager Digital Operations at Rolls-Royce, described one way that the on-site service staff and the control center in Dahlewitz cooperate. In one case, unusual vibrations appeared as fluctuations on a curve for an engine from the 715 model line, a predecessor to the Pearl 15. When problems like this arise, Rolls-Royce specialists diagnose the cause, give the service team instructions, and, if necessary, ship the replacement parts. "We can now prevent 98 percent of all threatened flight cancellations," said Voege. Now the company is going after the remaining 2 percent. While diagnoses have only been possible on the ground so far, the company's smart engines can record and evaluate thousands of para-

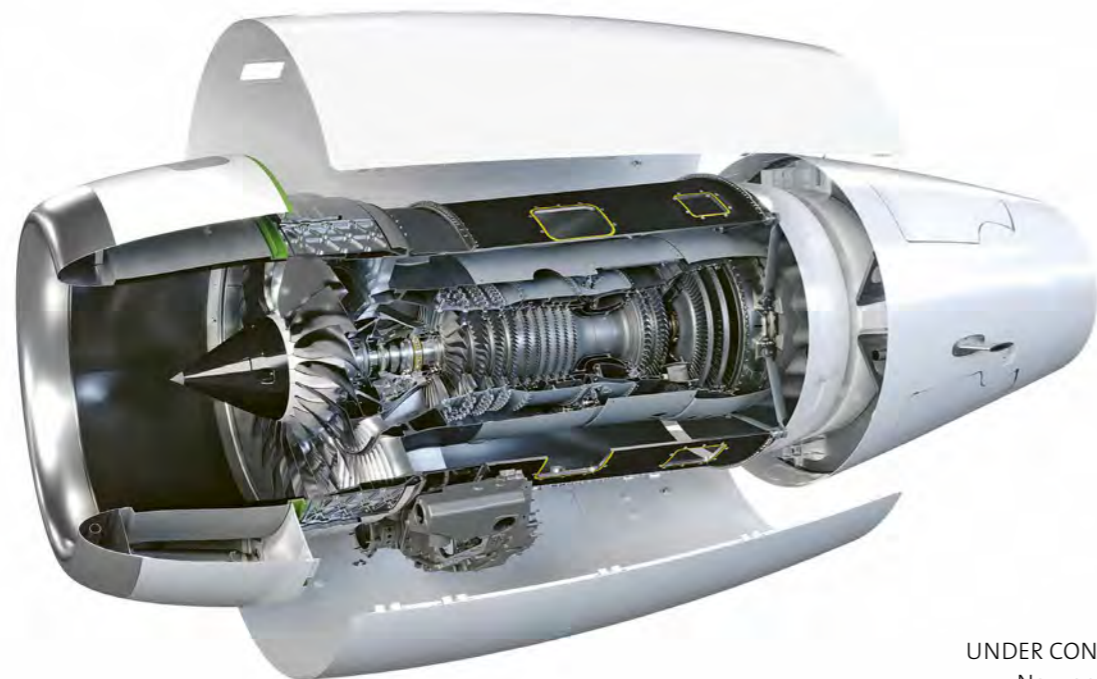
meters during flights, and even give pilots guidance on how to fly the plane as economically as possible.

To Rolls-Royce, digitalization means more than improved service. In 2017, the company founded its digital unit, the R2 Data Labs, and Caroline Gorski was named to direct it. Gorski, a historian, previously worked on developing the Internet of Things for a telecommunication company. "Data are the raw material for our transformation," she said, referring to the 30 terabytes of data that Rolls-Royce collects annually from just its engines. The evaluation of the data using artificial intelligence is opening the door to new services and innovative business models. The company is now building up the expertise it needs for this. For example, a new AI center has been created in Dahlewitz, part of a 100 million British pound investment. A portion of its mission to coordinate its work with external research centers such as the Hasso Plattner Institute in Potsdam.

Digital tools are now state-of-the-art technology in engine development. For example, new versions of engines are basically developed on computers using an automated design process. In just five minutes, hundreds of new variations of a typical



CUTTING DEVELOPMENT TIMES
Variations of familiar engines can be produced in a few minutes.



UNDER CONTROL
New engines talk to the pilot.

Rolls-Royce gas turbine engine can be worked out, a process that once took weeks. It takes just two additional days to narrow down the key characteristics for the unit, including weight, fuel consumption and noise emissions. Human activities only come into play after the potential of a model is clear – and it is right for the mission. "So far, it has been impossible to automate the actual design work to produce all the components in concrete form," said Uwe Minkus, who is in charge of ongoing efforts to standardize the company's design processes. Digitalization is the vehicle to do this. Its potential is clear from the example of a transmission due to be deployed in a large engine sometime in the next decade. If you were to calculate the output transmitted to the surface of the gear teeth operating in its transmission at full thrust, it would be the equivalent of about 10,000 horsepower applied to the surface of a finger. The distribution of the oil droplets and the wetting of the gear flanks in the gearbox are extensively simulated to create the best possible design for the cooling and lubrication of the gears.

Goodhead even envisions self-healing following the self-diagnosis of the engine someday. Early research on this is already underway. For example, the company is contemplating swarms of micro-robots that could inspect the engine from its interior, without having to dismantle it – a costly, time-consuming process. Beetle-like robots would scuttle out of a flexible hose leading into the engine through an induction tract. To reach the core engine through the compressor, they can be no larger than 8 millimeters. The concept is still ten years from series production, but one thing is certain: it's not just the mounds of data that will climb higher by then. The opportunities to use them will multiply as well. ©



Information on our seals for aviation applications is available here : <https://www.fst.com/markets/mobility/aerospace>



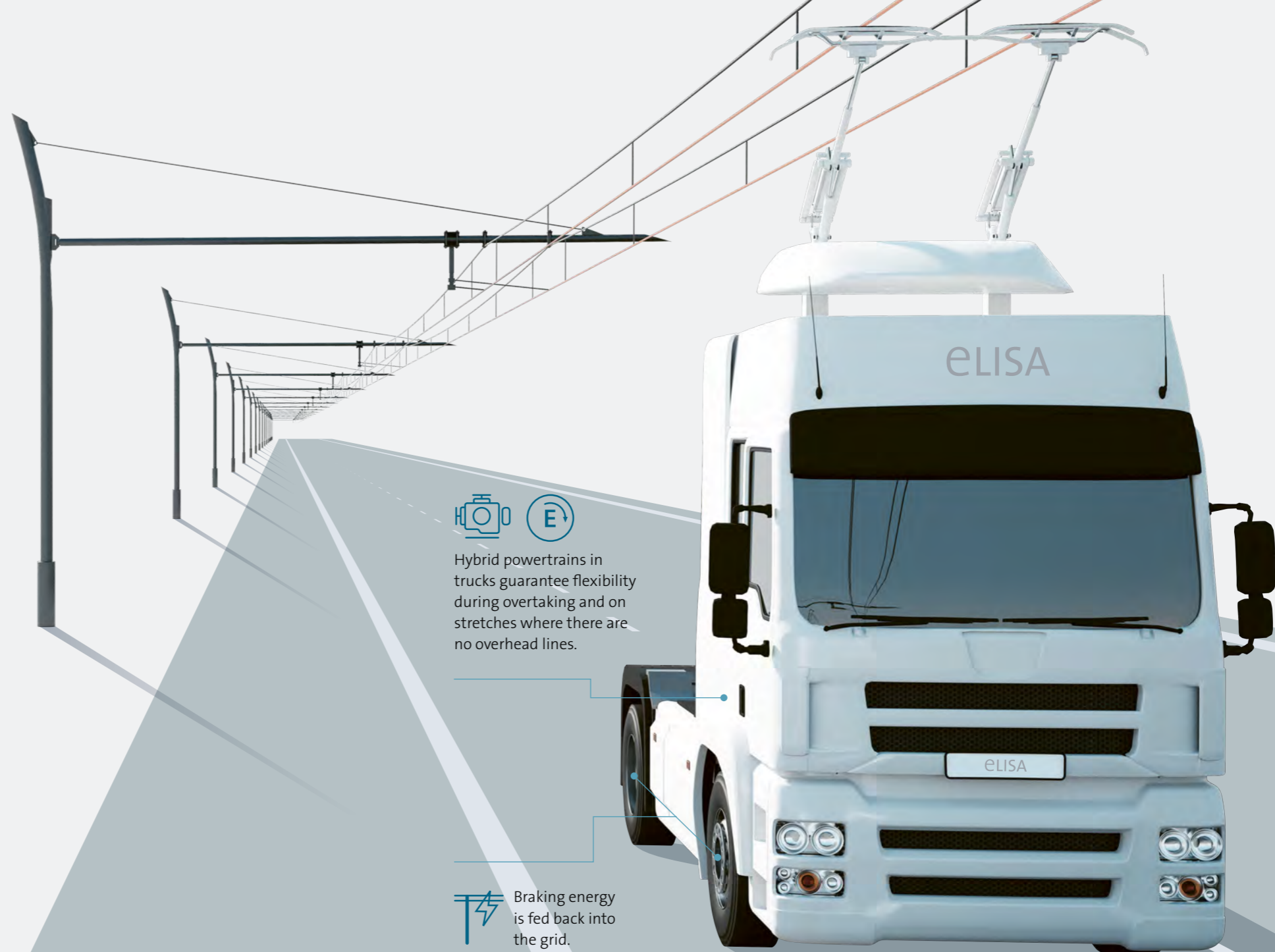
HIGH VOLTAGE

Building overhead lines for freeways and equipping trucks with pantographs – it sounds like science fiction. But if it works, the idea could contribute to a reduction in the rising CO₂ emissions coming from freight transport on roads. It is now being tested on a heavily traveled autobahn in Germany.

A truck goes by every nine seconds, and the interval between two cars is less than a second. South of Frankfurt, the A5 is one of the most heavily traveled stretches of autobahn in Germany. It goes through southern Hesse with four lanes in each direction. That makes it the ideal test lab for Gerd Riegelhuth, President of Hessen Mobil. A civil engineer, he is directing a project that is supposed to revolutionize freight transport on roads. If he proves successful, CO₂ emissions from this form of transportation could fall dramatically. The need is urgent, since truck traffic is steadily increasing. Calculations by the German Federal Environment Agency found that, even if two-and-one-half times as much freight were transported by rail, truck transport in Germany would grow about 60 percent by 2050. The situation looks even more bleak worldwide. Without countermeasures, rising prosperity will lead to a doubling of CO₂ emissions from road-based freight transport to 2.4 gigatons by 2050, according to the International Transport Forum.



Our solutions for electric mobility here:
<https://www.fst.com/expertise/battery-and-fuel-cell-technology>



Hybrid powertrains in trucks guarantee flexibility during overtaking and on stretches where there are no overhead lines.



Braking energy is fed back into the grid.

\$ 22,500

in fuel savings would be achieved by one German 40-ton truck over 62.132 mi of travel on an e-highway (figure from the year 2014).

56 mph

is the maximum speed at which a truck can automatically connect with and disconnect from an overhead line.

6,000,000 tons

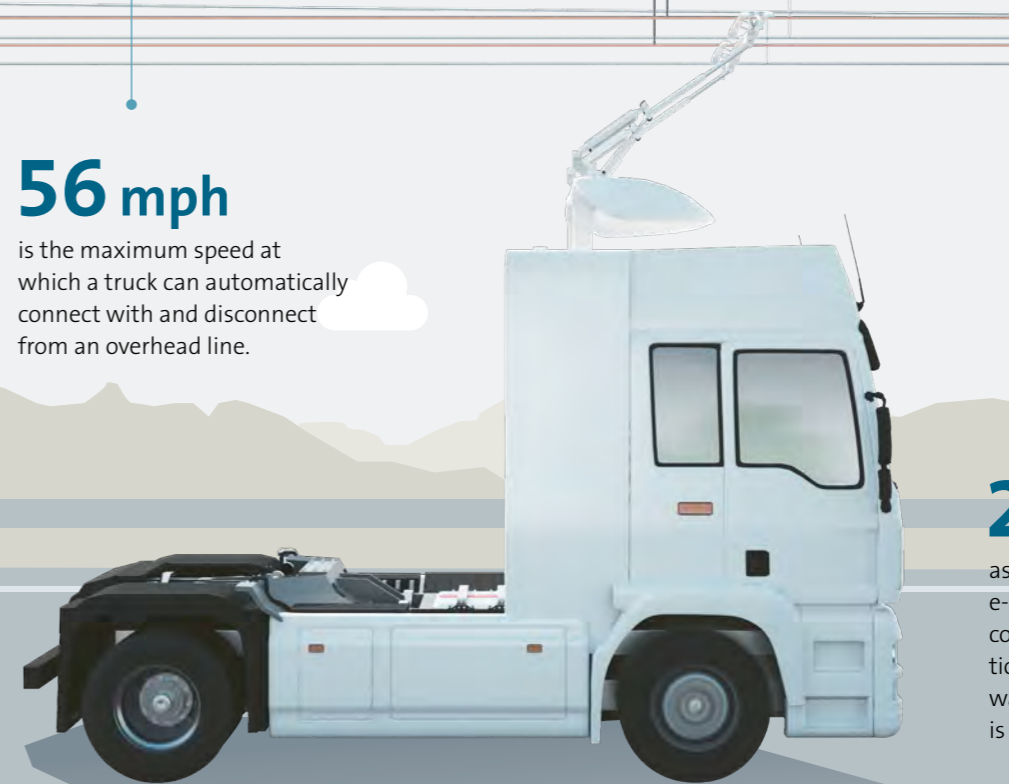
of CO₂ would be spared if 30 percent of the truck travel on German autobahns were electrified and supplied with renewable energy.

0%

local air pollution is produced by an electric powertrain.

2 times

as efficient: that is how an e-highway compares to a conventional internal combustion engine. To put it another way, the energy consumption is cut in half.



Toughest Field Test Yet

To prevent this scenario, the truck of the future must run on renewable energy, especially on solar and wind energy. This is not a trivial proposition. Experts estimate that a 40-ton truck would have to carry a 7 to 10-ton battery to even approach the range of today's diesel truck. To deal with this issue, a consortium including Siemens, Scania and some other participants have been working on a truck that would use overhead wires. After thorough tests at a former military airport in Brandenburg, the German Federal Institute for Highways proclaimed the technology to be basically suitable for use. The first tests on public roads have been underway in Sweden and southern California since 2017, but on fairly short, less-traveled stretches. The technology still needs to pass the toughest field test. Under Riegelhuth's direction, it starts in May 2019 on a 5-kilometer (3 mi) segment of the A5.

Preparatory Measures

Electrification of the stretch of road has been completed since late 2018, after just a year and a half of construction. The right driving lane in both directions was equipped with an overhead line, supported by a total of 231 masts. The electric current will be fed to the system by two substations, one for each driving direction. They obtain their electric current from a medium-voltage network and convert it from 10,000 volts to 670 volts. The current also has to be rectified; while the grid operates with alternating current, direct current is required for the contact

wires. The electric infrastructure basically corresponds to the systems familiar to users of trolley buses – from Switzerland, for example. The system lacks rails for electrical grounding; this is what mainly differentiates it from normal rail technology. Two contact wires are installed — a positive pole and a negative pole. They not only deliver the current – they also can be used to feed the energy produced on board (from braking, for example) back to the grid.

Pantographs for Trucks

The truck itself is the greatest technical challenge. It needs a current receptor, called a pantograph, that takes up as little space as possible. It also has to extend out and withdraw safely at full speed. Otherwise, it wouldn't be possible for a truck using overhead wires to overtake a slower vehicle or continue on its route if a lane were blocked. The researchers now seem to have found a solution after numerous tests. The pantograph lies on the roof of the cab and a two-part swivel arm guides it to the overhead line. The arm sits on an electric control center that is housed right behind the cab. This takes up a half meter (1.6 ft) of cargo space, but it was three times as large when engineers first began to experiment with its design. A dozen sensors, including a laser scanner, monitor the position of the pantograph, not just as the receptor is pressed against the overhead line, but during the entire trip.

Hybrid Solutions in Demand

The greatest advantage of trucks compared to freight trains is their flexibility – in theory, they can access any public street at any time. It is clear to advocates of pantograph-equipped, electrically-powered trucks that these vehicles must preserve this capability. Otherwise, they won't get access to logistics companies. As a solution to the problem, all Scania trucks are designed as hybrid vehicles; they have an economical diesel engine that takes over whenever the vehicle travels on a non-electrified route. That is almost always the case after it exits a freeway. It also does not make sense to electrify every stretch of autobahn. A study by the German Federal Ministry of Transport found that 80 percent of the heavy-duty trucks registered in Germany could use the technology if just 30 percent – or about 4,000 kilometers (2485 mi) – were outfitted with overhead wires. So far, there are no comparable figures for global merchandise transport, but the transportation of goods is concentrated in major economic centers. The 94 large cities that have joined the C40 climate protection initiative represent one quarter of the world's economic output.

Climate-Neutral Alternatives

Trucks can still operate in a climate-neutral mode when there are no overhead wires available – by not using fossil fuel in their diesel engines. Instead, they could burn a synthetic energy carrier produced with green electricity. Or the diesel engine could be replaced by a fuel cell that runs on hydrogen, provided

that the gas is produced in a climate friendly way. Freudenberg Sealing Technologies is now arming itself with both technologies. For example, investigations at the company's material labs are finding that the seals used in today's fuel systems are also suited for substitute diesel fuels – if they are designed correctly. In parallel, Freudenberg Sealing Technologies is not just working on components of fuel cells – in the future, it also intends to provide the technology as a complete system for niche markets.

Test Phase until 2022

In 2022, it will become clear whether pantograph-equipped trucks will at least be a partial solution for climate-neutral freight transport. At that point, researchers will have the results of the field test on the A5, which started out with five vehicles. They have to prove themselves under real-life conditions at five mainly small- and medium-size companies. During the project, researchers from the Technical University Darmstadt are collecting the large amounts of data that would be needed if a fairly extensive infrastructure were ever to be built. For example, they are interested in knowing how much electricity the trucks will use and what the network loads will be. Riegelhuth is excited about learning the results, but he notes soberly: "There is no global formula for climate-neutral transportation." Instead of lamenting that fact, he says: "We should always ask ourselves: What can we contribute?" ©



HAVE GOOD BEHAVIOR – SEEKING SOCIAL POINTS

OMNIPRESENT CAMERAS
In Chinese cities, software
assigns faces to real persons
automatically.



To some, it is the road to total citizen surveillance. To others, it is a way to provide greater fairness – in the people’s daily work with one another and especially in their business lives. China’s social credit point system is still in the pilot stage, but it has already spurred discussion – especially in the West. What’s behind it?

A report from Beijing.

Yet another city is starting to keep track of digital social points. Since early March of this year, a social credit point system has been up and running in Wuxi, a metropolis of 6 million people in Shanghai’s hinterlands. City officials say it uses Big Data analyses and cloud technologies to calculate social points for the city’s citizens based on no less than 493 criteria – including behavior in traffic, morality, the repayment of loans and commitment to charitable work. As a warm-up, Wuxi plans to launch pilot projects to “promote credibility.” The flowery language is one way to encourage good behavior in tourist hotspots and even in sanitary facilities, among other places.

The program is one of dozens of local social credit pilot projects in China. They are the vanguard of a nationwide

system that Beijing envisions, though its future characteristics are still up in the air. But one thing is clear, the system will take advantage of the new opportunities offered by digitalization. Networked monitoring cameras will record faces, according to this vision, and algorithms will assign them to individuals. Experts expect Big Data analytics to analyze events.

Wuxi is a modern city in the booming Yangtze River Delta – and one of the pilot cities for China’s Smart Cities initiative and for autonomous driving. Wuxi has installed a network infrastructure governing about 200 traffic lights since 2017. The city started out with the tests of car-to-car and car-to-traffic-signal networking. They are based on the LTE mobile wireless standard, which does not quite enable the real-time



SOCIAL POINTS
Foreign critics fear universal surveillance. China sees it as an incentive for proper behavior.

“THOSE WHO ARE WORTHY OF TRUST BENEFIT WHEREVER THEY GO, WHILE IT IS DIFFICULT FOR THE DISCREDITED TO TAKE A SINGLE STEP.”

transmission of data at this point, but it comes quite close. This infrastructure is now expected to help gather personal data on driving behavior for the city's social point system.

To foreign critics, this may seem like the first step toward an all-encompassing monitoring system. In China, however, it is presented as an inducement to upstanding behavior. The key term is “xinyong,” or trust. This virtue has often been lost in Chinese society. After scandals over baby formula adulterated with melamine, the contamination of stored blood and vaccines, and excessive pesticide use in agriculture, growing numbers of Chinese mistrust medicine and doubt the safety of their foods. And they mistrust other people. So it's no surprise that the Chinese are reacting positively to the new social credit system.

According to the first official draft by the State Council in 2014, a nationwide

point system of social credits is supposed to emerge. “Those who are worthy of trust benefit wherever they go, while it is difficult for the discredited to take a single step,” it said, summing up the concept. The term social credit represents a series of plans that the government wants to use to promote integrity, trustworthiness and security in its citizens' economic lives. “This is more of a political concept and an ideology relating to the use of data than a single project or system,” said Jeremy Daum of the Yale Law School, who has translated a series of Chinese legal texts on social credit into English.

The system can also show its teeth, which is evident from a nationwide blacklist of people subjected to enforcement actions, such as fines, in court verdicts. By coordinating various agencies, delinquent citizens are prevented from buying tickets for flights or first-class travel on high-speed trains. The highest

court in Beijing, China's capital, has ensured that local authorities such as the tourism agency or the Bureau of Civil Affairs integrate the data on those individuals into their systems, according to Kou Fang, the court's Interim Chairman. “This facilitates automatic comparisons, interception and ultimately penalties,” Kou said. The approach also blocks the monthly participation of these persons in the Beijing lottery for a coveted car license plate. In all of China, more than 18 million people were prevented from buying airline tickets since the introduction of the blacklist, and another 5.5 million were unable to buy train tickets, according to official figures. In addition, passengers can be penalized for misbehavior on trains or in airplanes. Since the Chinese present identification when they buy train tickets for designated seating, a disruptive traveler can be identified in videos from the monitoring cameras in the railway cars. A more distant goal is digital face recognition, which is being tested at street crossings in scattered locations.

The current plan to build the system runs until 2020. In Daum's view, it will be followed by another plan with new goals. It is not envisioned that the system will be extensively used by then, as some media reports have said. But the pilot projects are an indication of where the efforts may be headed.

EASIER CREDIT

The eastern Chinese city of Rongchang assigns its citizens to categories ranging between AAA and D. Each starts out with 1,000 points, which can increase or decrease in 200 different ways. There are pluses for donating blood, volunteering, reporting counterfeit products to authorities, or brokering investments in the city. There are minuses for tax evasion, traffic offenses or violations of the country's family-planning policies. AAA citizens receive free health physicals, 30

cubic meters of free tap water or heating bill abatements. On the Yangtze, the metropolis of Nanjing uses Big Data and credit information to create a so-called credit image of all its companies. “The tax agency gave my company an ‘A,’ enabling us to quickly get a 2-million yuan (263,000 euros; 296,284 US dollars) loan from the local bank,” the firm's founder, Wu Jianhui, told a local newspaper. Wu needs the money to relocate his company.

Business life is one key area where China would like to reestablish trust. This extends to credit reports, which are very much like their counterparts in the West. But in 2017, they only covered about 300 million people, or less than one quarter of the population, in the central bank's system. The credit point systems are designed to solve some of the problems. For example, at many banks, young people are almost automatically denied loans. The situation is similar for many small and medium-sized private companies: They have a hard time getting loans from government-owned banks. Due to the lack of credit reports, appeals to the government for more loans to private companies come into direct conflict with efforts to reduce risks in the financial system.

Meanwhile, according to the National Public Credit Information Centre, some credit databases have created a blacklist containing nearly 3.6 million companies that are not making payments on outstanding loans, that are involved in consumer scandals, or have run misleading ads. The upshot: they are not allowed to take part in government bids and land auctions or issue bonds. There are, in fact, private companies that operate parallel digital point systems, but they resemble evaluation models like those from online department stores or bonus programs. The best-known and largest is the “Sesame Credit” system established by the Internet firm Alibaba, which

operates online department stores such as Tmall and the payment service Alipay. It is unclear whether these private systems will someday be networked with future governmental social credit systems – or whether the information is already flowing to the government. Most Chinese, however, have insisted on relatively low levels of data privacy so far and welcome the incentives for greater decency in business and on the road. ©

CATEGORIES FROM



AAA to D

STARTING OFF WITH



1,000 Points

MEASUREMENT



200 Types

E-GOVERNMENT

e. g., registering for pre-school, applying for welfare, ordering a passport

E-HEALTH

e. g., switching family doctor digitally



SMART CITY

e. g., real-time assessment of traffic and parking situations, traffic jam reductions



E-ECONOMY

Digitalization of companies



MORE THAN HYGGE

Denmark has held the top spot on the EU's digital ranking for years. This is most evident in Copenhagen, the country's capital. Digitalization at companies and in public administration is highly advanced, and many startups have emerged. Here three of Copenhagen's digital pioneers describe their daily lives, which involve far more than "hygge," the quintessentially Danish sense of comfort and coziness.

In 2015, the Danes were in first place in the rankings of the 28 EU states, just ahead of Sweden, and they continued to lead in 2016 and 2017. And they were acclaimed the victors again in 2018. In the EU's official digital ranking, the "Digital Economy and Society Index" (DESI), the Danes have held the high ground for years. The index compares key parameters that indicate the degree of digitalization in individual EU member states: the connectivity within the countries, the digital skill sets and their use by the population, the digitalization within companies, and the range of digital services in public administration. Denmark seems to have locked in the top spot. This is especially clear in the country's capital, Copenhagen. Whether you want to register a change of address, apply for social services or report a pothole to the public works department, each action takes place digitally – over the Internet. And fast Internet is widely available in rural as well as urban areas.



FRANK JENSEN
Mayor



Digitalization is expected to give citizens a clearer picture of their rights and duties – and to put them at ease about them. The city's Internet-based public administration, also known as "E-Government," is a high priority there as well as in other Danish communities. The most used "digital self-services" fall into a number of categories: waste management, switching to another family doctor, ordering a passport, registering for nursery school, and applying for social aid. The goal is always to make life in the city more pleasant. One of the highly practical services is a text message subscription that provides information on which waste will be collected the following day. In most inner courtyards, various barrels are available for domestic trash, bio waste, plastic and electrical scrap, and it is easy to confuse them. Jensen seems to have realized that you have to deal with the details to make a town the "best city in the world."

Pastor's Son with Digital Ambitions

It's safe to assume that churches are rarely considered the main target group of a startup, but Christian Steffensen has specialized in precisely this type of customer. When he founded his company, Churchdesk, he was in his mid-20s. Churchdesk helps congregations in Denmark, the United Kingdom and Germany organize their work and communication with their members.

Steffensen seems to be the perfect entrepreneur for this. He originally wanted to be a pastor like his mother. "But the theological studies I would have needed held me back," he said as he sat at a long dining table at Churchdesk's office

A Mayor with a Digital City Hall

When a city is a role model in a certain area, its status almost always has something to do with politics. In Copenhagen, it is, above all, social democratic politics. Frank Jensen is the ninth mayor in a row from the Social Democratic Party.

"Smart" – with all of its positive as well as negative connotations – is arguably the right word to describe Jensen. He is in his late 50s and comes from North Jutland, Denmark's northern mainland. He has carved out solid careers in politics and business as few other Social Democrats have. Given his life story, it is no surprise that he earned a reputation as a move-and-shaker during the nearly ten years he has spent running Denmark's capital – and less so as a visionary who gave fiery or intellectual speeches. Jensen, an economist, long held a seat in the Danish Parliament before he became the director of a telephone company and later an attorney association. Voters in Copenhagen elected him mayor in 2010. His objective: "I want to work hard to make sure that Copenhagen will continue to be the best city in the world."



CHRISTIAN STEFFENSEN
Founder of Churchdesk

in Copenhagen. "I went to the Copenhagen Business School instead. I had always been interested in the way organizations might be changed with the use of software. I wanted to combine this with my interest in the church." Steffensen's office space doesn't much look like a place of worship. The visitor sees the usual startup atmosphere, complete with work islands and the inevitable foosball tables.

The congregations can use Churchdesk to manage their members' data, invite them to services and concerts by email, organize internal communication, and plan for their staffing needs. "Whether the topic is choir practice, funerals or marriages, there are many appointments with full-time and voluntary staff that the congregations have to plan," Steffensen said. "Even today, churches are the organizations with the highest membership. But the fact that many members are passive is a challenge." Steffensen wants to use the software to help activate them.

Churchdesk has offices in London and Berlin in addition to Copenhagen. Steffensen often visits Germany and is aware of national differences. "Data security is more important in Germany," he said, so Churchdesk stores all the data on servers in that country. In general, German churches do not use the Internet as extensively as those in Denmark. Many German newsletters are still printed even though there is an online version. The reason could be that Germany has to deal with challenges that Denmark no longer face. "Unlike the situation in our country, there is often no fast Internet in the German countryside," Steffensen said.

"UNLIKE THE SITUATION IN OUR COUNTRY, THERE IS OFTEN NO FAST INTERNET IN THE GERMAN COUNTRYSIDE."

ANNA THORMANN BOESEN
"Gate 21" program manager



The Woman Who Tackles Traffic Jams by App

Anna Thormann Boesen's work would be much more difficult if so many Danes were not as fond of technology as they are. "It's funny – I used the GPS function on my smartphone and looked on the map to get here in my electric car, even though I was very well aware of the way here," she said in an interview in a restaurant in Copenhagen's Islandsbrygge neighborhood. As the Danes put it, Thormann Boesen is "can tec soc," meaning that she studied social sciences with a technological orientation. Today she is the program manager for sustainable mobility at "Gate 21," a company owned by municipalities and commercial firms that want to make growth more sustainable. This includes making transportation more environmentally friendly and efficient.

For example, the city has the somewhat old, yet still important Glostrup train station, along with an adjacent roundabout, on its west side. They are both bottlenecks because the people who work in the area and live in the inner city all drive by at about the same time. The traffic streams are measured at Glostrup, and the path of everyone carrying a mobile telephone is recorded. "This naturally happens anonymously. It makes it possible to calculate when certain points such as the roundabout will be overloaded," Thormann Boesen said. Other commuters then receive a simple notification via an app: whether you are in the office or at home, stay a little longer where you are – because if you leave, you won't get to your destination any faster than if you were to wait another fifteen minutes. "Technology and the fact that we Danes like to use it make it possible to optimize the traffic flow," Thormann Boesen said. "It works – without constantly building more or wider roads." ©



WORKING HAND-IN-HAND WITH COBOTS

Some have two arms, others only one. They roll through plant aisles or are enthroned on pedestals. Robots are increasingly working with people today.

Unlike classic industrial robots, cobots are small, lightweight and flexible. They even handle monotonous work for people. They are already in use in the Simmerring® final assembly area at the main Freudenberg Sealing Technologies factory in Weinheim.

At first glance, the new coworker in the Simmerring® final assembly area seems quite unremarkable. He neither rotates his head 360 degrees like R2-D2 in Star Wars nor does he speak in a tinny voice. Instead, he is enthroned on a pedestal from which he is unable to descend. His body is actually just an arm. But at least he is able to move it along seven axes, and it is equipped with a gripper. He perceives his environment with two cameras (one of them close to the gripper), and he has a monitor for a head. If you switch it on, a face appears. The eyes are still closed when the cobot is booted up. He later regards his counterpart with large round eyes.

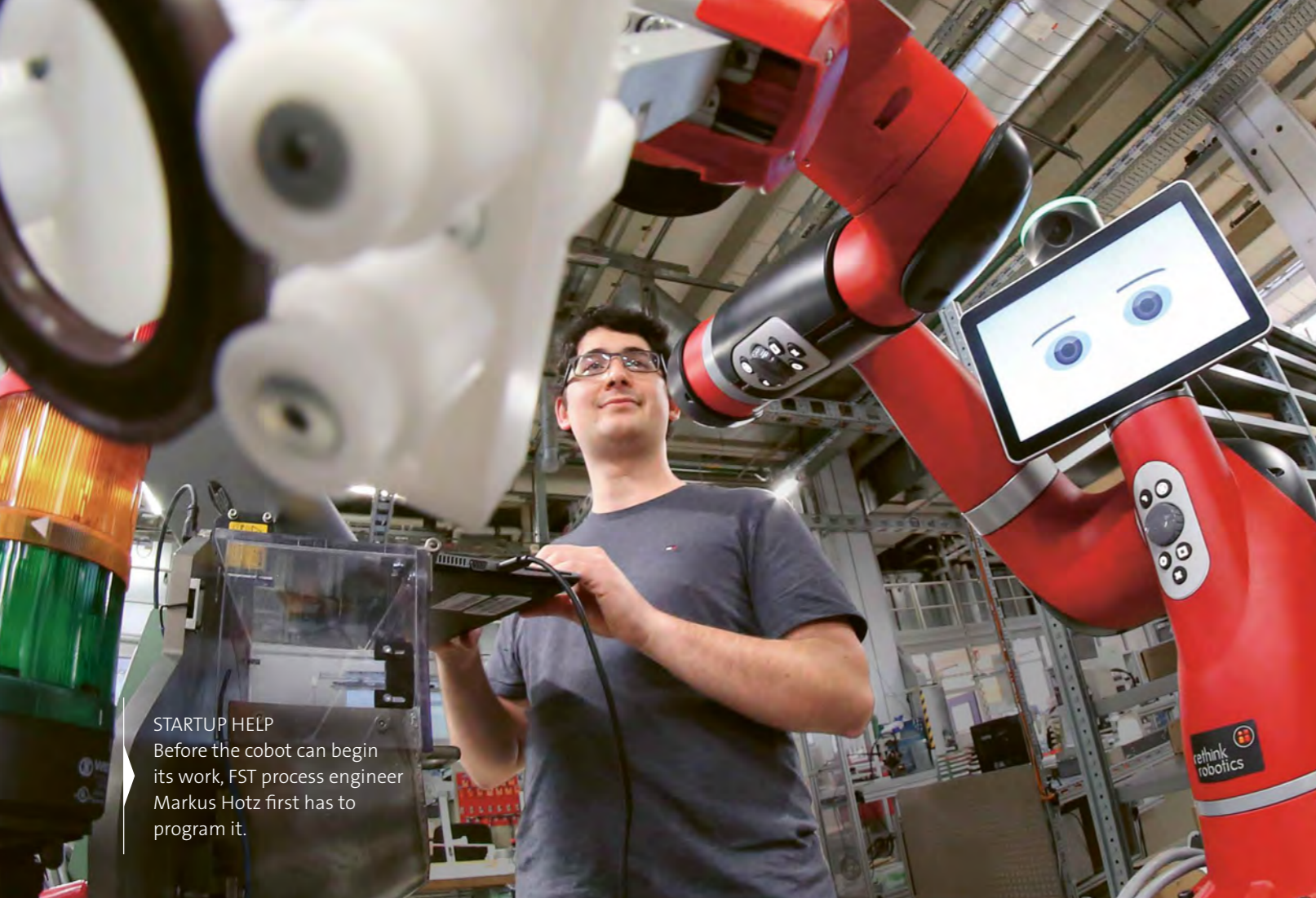
The new colleague in Weinheim is a cobot. This variety of robot was created to collaborate with human beings. That is the origin of its name: cobot is short for “collaborative robot.” For years, industrial robots have not been able to work hand-in-hand with people. They could only work within cages for safety reasons. Cobots, on the other hand, are small, light and agile and are designed for small loads and slow speeds.

The first examples were developed in the United States at Northwestern University in 1996. Today they are preparing to conquer shop floors everywhere. “Freudenberg Sealing Technologies is currently using cobots at eight locations,” said Ralf Maisack, who is pressing ahead with the strategic development of cobots in the company’s Technology & Innovation unit. “For example, a stationary, one-armed robot has taken over simple assembly tasks at the Findlay facility in the United States. We are also using a two-armed cobot in Luserna, Italy, and mobile cobots in Bristol and Newcastle in the UK.”

In Weinheim, Markus Hotz takes care of one-armed robots. Hotz, a process engineer, did his bachelor’s thesis on these mechanical coworkers. “Cobots are especially well-suited for manual activities that are constantly repeated,” he said. “If they relieve workers of these tasks, the latter can deal with higher-value activities – and manufacturing output rises overall.” One of his protégés works with a human colleague in final Simmerring® production and mainly handles two tasks: first,



READY TO GO
The cobot has an arm with a gripper that it can move along seven axes.



STARTUP HELP

Before the cobot can begin its work, FST process engineer Markus Hotz first has to program it.

“IF ITS ARM IS STRUCK WITH A FORCE OF MORE THAN 20 NEWTONS, IT WAKES UP AND GOES INTO ITS WORK POSITION.”

Simmerring® production and mainly handles two tasks: first, it has to mount a spring in a Simmerring® and then fill the unit with the right quantity of grease. That certainly sounds simple, but since the cobot is not built precisely for this task, it has to be programmed first.

A human worker is required at the start. At the beginning of his shift, he has to get everything ready. For instance, he has to check the amount of grease that is brought into the application station. He also loads the stock of Simmerrings® onto a bar feeder that will later deliver individual Simmerrings® via a dispenser. The worker then gives his cobot the signal to start. Incidentally, this is done very rudely – by giving it a shove. “The cobot is equipped with force and torque sensors,” Hotz said. “If its arm is struck with a force of more than 20 newtons, it wakes up and goes into its work position. The contact need not be very brutal – 20 newtons corresponds to the gravitational pull that acts on an object weighing 2 kilograms (4.4 lbs).

After it is booted up, it has to orient itself. The cobot uses its cameras to look for position markings in the form of QR codes that are attached to its workstation. That is how it recognizes where it is. Then it uses its arm to pass over the table where he will later deposit finished parts, to make sure no obstacles are in its way. “The cobot is basically designed for collisions and could easily bump into a person,” Hotz said. “But this isn’t dangerous because it only works with low forces and at low speeds.” When its sensors detect an obstacle, it stops immediately. If the obstacle then disappears, it starts out again in slow motion until it can be sure that the obstacle is completely gone. The areas for the cobot and the human being are precisely marked with red lines. The robot’s radius of action is relatively limited – 1.2 meters (3.39 ft).

But that’s enough for the cobot to do its job. First of all, it reaches into a dispenser and removes a Simmerring® from the bar feeder. Then it swivels toward a specially developed workstation and presses the Simmerring® onto a cone so that the metal spring to be mounted springs at precisely the desired point. “We’ve honed this concept to a high degree,” Hotz said with a grin. “But this shows that even a cobot doesn’t work alone.” The cobot then takes the Simmerring® off the cone again, moves it to the lubricator and presses it with positive-locking onto a lubricating mandrel. “Here the crucial factor is that the cobot is linked with the machine control system via a data cable,” Hotz said. “This allows it to communicate with the system and actively trigger the signal to perform the lubrication.” The quality control after the lubrication is also important. It is only when the machine reports that the process has functioned error-free that the cobot removes the Simmerring® from the lubricating mandrel, swivels to a delivery table and stacks finished products by the dozens. A human being is then needed to carry out the final inspection and package the rings.

“BUT THIS ISN’T DANGEROUS BECAUSE IT ONLY WORKS WITH LOW FORCES AND AT LOW SPEEDS.”

The final-assembly process at the Weinheim facility is proving to be stable and reliable. This form of teamwork has many advantages. The worker can concentrate on the production set-up, quality control, and packaging, and is relieved of especially monotonous work. The highly flexible cobots demonstrate their strengths when ergonomics of the activity is poor. They can move their arms along many axes and reach areas that are difficult to access. These new coworkers are an aid to workers – they are not a replacement for them. “A cobot never works alone. It always works with a human being,” Hotz said. “One needs the other.” Since the speed and strength of a cobot are limited for safety reasons, it is suited for work with medium degrees of automation and complexity. It only rarely matches the speed of a human being in its work. In Weinheim, cobots are thus planned for other points in the final processing of Simmerrings®. This will lead to new, exciting tasks for Markus Hotz, since there will certainly be opportunities to tinker during the set-ups. ©



Another article on cobots can be found here:
<https://bit.ly/2FVklSg>



TRANSPARENT PRODUCTION

A modern technology district has been built in Berlin-Adlershof, where Germany's first powered aircraft were tested early in the 20th century. Freudenberg Sealing Technologies has operated an automotive components plant there since 2011. Its IT backbone, the Manufacturing Execution System (MES), is considered an important step on the road to Industry 4.0.

More about FST sealing bellows at <https://www.fst.com/products/special-sealing-products/boots>



DR. MATTHIAS GÖTZFRIED
is in charge of the Freudenberg Sealing Technologies plant in Berlin-Adlershof.

A fairly large group of young passengers were taking the S-Bahn from central Berlin to the southeast portion of the city, a trip that lasted a good half-hour. One of them was working on his tablet en route. Its operating system used Chinese characters – he had the editor open and was apparently doing some software programming. At Adlershof, the group assembled, emerged from the train and fanned out through the neighborhood and campus after departing the station. Today, where Germany's first motorized aircraft were once tested, a number of institutions have sprung up: five technology centers, ten non-university research institutes with 1,700 employees, and the mathematics-natural science campus of Berlin-based Humboldt University. And not least of all, a manufacturing facility. Freudenberg Sealing Technologies (FST) has been manufacturing axle boots and sealing bellows for use in automobile chassis here since 2011. The plant employs a staff of about 220, and 100 million parts leave the plant each year.

"Berlin-Adlershof describes itself as Berlin's smartest neighborhood, and we see a great deal of dynamism and creativity here," said Dr. Matthias Götzfried, who manages the Freudenberg Sealing Technologies plant. "The combination of startups and established companies, in particular, is exciting. This makes it possible to put innovative ideas into practice quickly." In the digitalization of manufacturing, for example. The plant's sealing bellows are destined for tie rod ball joints and transverse and longitudinal control arms. Produced in large volumes, they are nonetheless specially designed for each

customer. So Berlin Adlershof is not purely an FST manufacturing operation. "We have all the functions of a small company here, and even employ our own development engineers," Götzfried said. Because the geometry of the bellows and the arrangement of the seal lips continually vary, the production process has to meet stringent requirements. For example, manufacturing engineers have to constantly reset the tools and adjust processes. "To digitalize these processes, we introduced a manufacturing execution system in 2014," Götzfried said as he stepped into the manufacturing area.

The machine park here is divided into two large production areas with seven production lines. Containers for the finished products are positioned between them. When the machines are running, the noises that most of them make are monotone. "Previously, we worked with many manual notes on paper regarding raw materials, production goals, scrap or particular machine parameters," Götzfried said. "Today our production is digital. The data are read directly from the machines and are available in real time." On one hand, the Manufacturing Execution System (MES) links the machine data with the overarching ERP system, which is used to control the material supply, among other things. On the other hand, it establishes the connection to the machine park in the manufacturing area.

The MES prepares the data on a homepage that employees can call up with a tablet. When a machine displays the color "green," it is running trouble-free at the target output.

“Yellow” indicates that the particular machine is running but not at the target output. If it shows “red,” an unscheduled stoppage has occurred. At this point, the shift leader or the maintenance worker immediately checks the tablet to see which machine is affected, where it is located, precisely how long it has been shut down, and what the cause was.

“Whether a metal part jammed, a target temperature was not reached or the tool was not positioned precisely, the machine must be brought to a halt. This enables employees to quickly correct the error,” Götzfried said. “In each case, it is especially important for us to integrate MES directly into our processes. For example, stoppages are displayed as pop-up reports that have to be acknowledged by the responsible MES persons.” Because the data are available in real time, the fitters and maintenance staff can respond more quickly than in the past, directly increasing uptime and output, that is, the number of properly manufactured parts. Shift leaders and production and plant managers are able to call up key operating data, such as output as a percentage reflecting actual versus target volumes, or more detailed operating figures showing availability, cycle time, scrap and other values.

The mass of data is also made available to Freudenberg Sealing Technologies process engineers. Based on documented error profiles, they can optimize machinery operation and take action ahead of time to prevent future errors. For its part, the maintenance staff uses the data to adjust the service intervals

to meet actual needs, to better integrate the interventions into the production processes. In any case, if a tool change is due, the work can be handled in a specific timeframe. “Our MES system also provides the data-driven basis for future proactive maintenance,” Götzfried said.

For Götzfried, the greatest challenge in the machine park’s digitalization is that it has mostly been built up over time. “Here you have highly modern machines standing next to older generations that you have to adapt for work with the MES system.” It is also crucial for employees to accept digital tools. The Adlershof plant has taken measures to promote this. One is a small digital team that does programming on site alongside the employees. The efforts are paying off. Before the introduction of MES, the plant had 4.6 defective parts per million units produced. Thanks to the optimizations, this figure has improved to just a single defective part in 2018 – and that was out of 10 million units manufactured.

Additional projects are expected to bring the plant further down the road to digitalization. For one thing, FST experts want to use the masses of captured data to enable AI learning systems to automatically adapt key machine parameters such as temperatures and cycle times to particular input parameters – for example, to information on the use of raw materials. Augmented reality methods are also expected to facilitate training on equipment maintenance and repairs with the help of virtual reality glasses. ©

CLEARLY INDICATED
Whether a particular piece of equipment is running, stopped or scheduled is visible right on the machine.

PRODUCTION
Freudenberg Sealing Technologies manufactures sealing bellows and axle boots for car chassis at its Berlin-Adlershof facility.



CONTROL SYSTEM FOR PRODUCTION

A Manufacturing Execution System (MES) makes it possible to control a factory’s production in real time. It connects the commercial system handling order management with the machine park, capturing important processing data as well as all the relevant operating and equipment data. Once processed, the data can be used to more effectively control production processes, resources and maintenance and to set up interfaces for material handling. One goal is to better coordinate orders with the materials used in production.



ALWAYS IN THE KNOW

MATERIALS
A seal's materials have to become electrically conductive to give it intelligence.

Until now, seals in the process industry have mostly been replaced as preventive measures at fixed intervals, but an interdisciplinary team at Freudenberg Sealing Technologies is working on seals that communicate their level of wear. The solution employs an electrically conductive material.

After Austrian engineer Walther Simmer co-developed the shaft seals bearing his name at the Carl Freudenberg Lederfabrik in Weinheim in 1929, they began their advance around the world. They were deployed in vehicles, industrial equipment and many other areas of application, sealing off machine housings at the point where shafts or pushrods, for example, emerged and providing protection against environmental influences. They have performed these services reliably – and quietly – right down to the present day. One result of their introverted nature: most seals are replaced before the end of their service lives – as a preventive measure, so to speak.

What would it be like for a seal to provide information on how it is doing? And when exactly it would need to be replaced, when there is not much left of the sealing lip? That is the question that a cross-disciplinary research team posed at Freudenberg Sealing Technologies facilities in Weinheim and Reichelsheim. Working with a client in the process industry, the engineers wanted to develop a seal that measured its level of wear – on its own. The goal was to capture data about the condition of the seal at any time. The advantages are clear. The maintenance of processing facilities – in this case, bottling plants for foods such as milk or ketchup – could be carried out when it was needed, permitting longer maintenance intervals. The maintenance staff could also improve the way the work fit into the operational flow. Most importantly of all, unplanned stoppages at bottling facilities due to leakage would become a thing of the past. Plant operators do all they can to prevent them since they lead to expensive production losses.

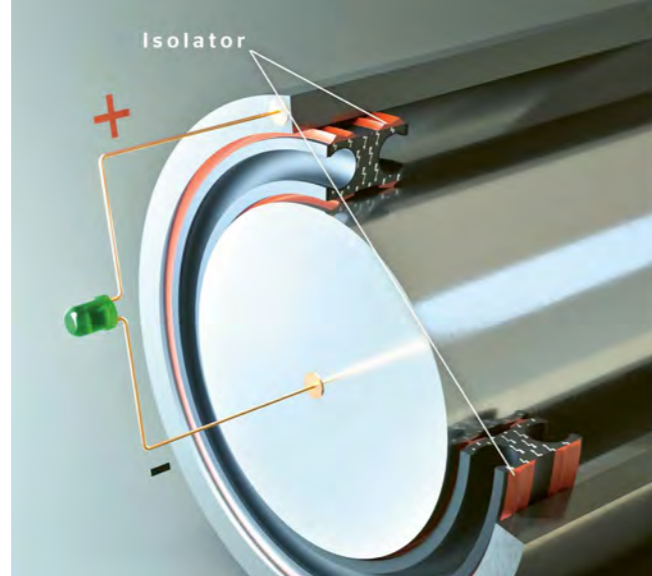
“Once the task was defined, we began by looking at the opportunities that physics offers,” said Dr. Boris Traber, who is in charge of the development of new materials at Freudenberg

Sealing Technologies. Seals are primarily made of elastomers that cannot process signals in their pure form. It is possible to insert a sensor or microchip into seals to make them intelligent, but the integrated component would be a foreign body and could impair the seal's function.

“So we focused on approaches where the intelligence comes from the material itself,” Traber said. Researchers equipped sealing material with special fillers that make the elastomer electrically conductive. “That sounds quite simple, but it isn't,” Traber said. “This isn't just giving a rubber compound electric properties. The material's characteristics must be just as good as those of a conventional seal, such as a good setting behavior, use in a broad range of temperatures and effective resistance to media used in the process industry, including cleaning media.” Since the seals come into contact with the foods being bottled, they must only include permissible ingredients – those listed on the positives list of the EU and the U.S. FDA.

SEAL DETERMINES OWN LEVEL OF WEAR

The approach to design and measurement used to determine seal wear are just as important as the material itself. “In these cases, there are no general solutions. The methods have to be geared to the particular application,” Traber said. One possibility involves rod and piston seals in valves. They are among the most important components of a bottling facility because they control the flow of the processed commodity. The seal lip insulates the gap between the rod or piston and the housing. To determine the sealing lip's wear, engineers start out with two different materials for the seals. The actual seal body



MEASUREMENT PRINCIPLE

The seal lip serves as an insulator. If it is worn, the capacity between the electrically conductive seal body and the housing changes.

consists of an electrically conductive elastomer, while the seal lip consists of a non-conductive, insulating rubber. The piston is equipped with a connecting wire, and the housing serves as the ground.

A transducer on the outside sends an electric signal that reaches the seal via a wire. This creates voltage between the electrically conductive portion of the seal and the valve housing. In this case, the two electrically conductive surfaces form a capacitor, and the seal lip lying in-between insulates the two surfaces from one another. The more the seal lip wears, the less effective it is at insulating the two electrodes. This alters the seal's electrical capacity, which is proportional to the distance between the two electrically conductive surfaces. If you measure this change, you can deduce the condition of the seal lip.

"In our test stand trials, we have determined that the change in electric capacity is correlated with the expected leakage," said Olaf Nahrwold, who is in charge of design development. "This means this measurement principle is fundamentally suited to capturing seal wear." The cohesion of the two different elastomer mixtures for the seal body and seal lip – which was difficult at the beginning – has now been solved. "At the start, the individual materials separated from one another, but we have now found the right bonding method," Traber

said. The researchers determined the geometry of the electrically conductive seal body and insulating seal lip with the help of extensive simulations – since the precision can be improved with geometric optimizations. That precision makes it possible to draw conclusions about seal wear from changes in electrical capacity.

"The development of self-monitoring seals involved intensive teamwork. No one discipline would have been able to handle this by itself," Traber said. Material developers, product developers, process specialists and sensor experts work hand-in-hand with their coworkers from the operating departments, Freudenberg Sealing Technologies sales and the application experts at the customer's site. This made it possible for the first component tests to be run on an actual valve at an early stage to validate the product concept. The interdisciplinary team also added colleagues from production. "It doesn't help at all if we have a high-performing prototype that is hard to manufacture using a particular material mixture," said Thomas Kramer, Development Manager Special Sealing Industry. It takes a wide range of experts to get seals to communicate their conditions, but it's possible – that much is now clear. ©



Read more about this topic online at <https://www.fst.com/expertise/material-expertise>



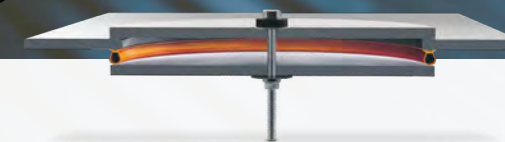
MAJORITY STAKE IN XALT ENERGY

Since the start of this year, Freudenberg Sealing Technologies has been the majority shareholder in XALT Energy. The U.S. company develops and produces lithium ion technologies for commercial vehicles.

The investment gives XALT Energy the ability to expand its production capacity as well as its research and development work on mobility technologies. With XALT Energy's help, Freudenberg Sealing Technologies intends to develop from a supplier to the market leader in mobility technologies and services. In light of the trends toward lithium ion batteries and fuel cell powertrains, it is imperative that its customers have the right materials, products and system solutions to solve complex technical challenges.

XALT Energy, which specializes in lithium ion technology for large, high-energy / high-performance accumulator systems, is a supplier to sectors such as logistics, railways and shipbuilding, along with the automotive and general industries. The company produces lithium ion battery cells, packs and modules, as well as the associated controls and software, on more than 40,000 square meters of space in its high-quality, automated clean room manufacturing area.

Freudenberg Sealing Technologies and XALT Energy offer advanced lithium ion battery systems to leading companies in the commercial vehicle sector, such as New Flyer of America. XALT Energy cooperates with automakers such as Fiat Chrysler, Ford and General Motors through the U.S. Advanced Battery Consortium LLC. ©



SEALING MATERIALS DURING FUEL TESTING

How do synthetic fuels affect the long-term stability of seals? Freudenberg Sealing Technologies assessed this in comprehensive tests.

Synthetic fuels can reduce the CO₂ emissions produced by conventional internal combustion engines. The liquid or gaseous fuels that are created from carbon and hydrogen with the help of solar and wind energy can be mixed with conventionally produced fuels.

In a series of tests, Freudenberg Sealing Technologies exposed various sealing materials to oxymethylenether (OME), a much-discussed synthetic fuel, for fairly long periods of time. The more the material swelled, the more its strength diminished, which led to a deterioration in its elongation at break. The measurements focused on volume expansion and the changes in mechanical strength of sealing materials such as FKM with different fluorine content, FFKM, NBR and EPDM. In the tests, they are stored in the test media for 168 hours at 125°C (257°F).

In nearly all the sealing materials, pure OME led to an increase in volume beyond the usual swelling values. Despite increasing fluorine content, the swelling volume did not even decline for the FKM compounds. The proportion of hydrogen is the reason for this. Accordingly, the more expensive perfluoro rubber (FFKM) displayed very good values. For an OME admixture of up to 30 percent by volume, all the tested FKM materials exhibited significantly reduced swelling. That means that a certain proportion of diesel could already be replaced by OME, even with the materials available today. ©



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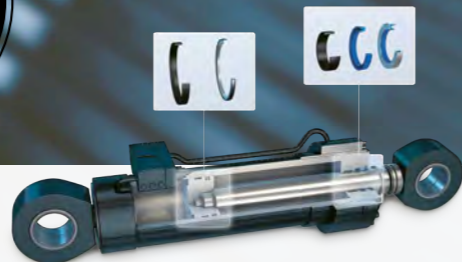
GERROMATIC: THE PERFECT WAVE

The Gerromatic rotary seal is superbly suited for use in the process industry. Thanks to its shape, it is self-cleaning, generates little friction and withstands higher pressures than other options.

The material being processed is in constant motion in production facilities such as those in the food and beverage industry. Shaft seals on the drive shafts keep liquids inside the system, but the often-used rotationally symmetrical seal lips are susceptible to friction, which leads to higher temperatures. That increases wear and reduces the system's efficiency. There is also the threat of leakage if the pressure on the seals is too great.

Freudenberg Sealing Technologies has given its new Gerromatic rotary seal a wave-shaped seal lip. It withstands significantly greater pressure than other options. Its sinusoidal contact path reduces friction as well as temperature increases. The seal, which is self-cleaning and long-lasting, is subject to less wear. In a standard, 96-hour "wet running" test, the temperature increased 20°C (68°F) less than the rise for a standard seal. Its leakage was vanishingly small on a test run of more than 1,700 kilometers (1,056 mi).

Multiple versions of the Gerromatic are made from the thermoplastic polymer PTFE, which is available with food-related approvals under EU 10/2011 and the FDA as well as pharmaceutical approvals under the U.S. standard USP Class VI. The material is temperature-resistant from -80°C to +200°C (-112°F to +392°F). Another advantage of PTFE is that it is highly resistant to the media used for cleaning and sterilization in the process industry. ©



PERFECT CYLINDER PROGRAM

Freudenberg-NOK Sealing Technologies has developed the Perfect Cylinder program. The new approach helps customers reduce the production costs for hydraulic cylinders while increasing equipment output and operating life.

Manufacturers are constantly modernizing parts of their machines to ensure that heavy-duty vehicles can operate without disruption in agriculture and the construction sector. Freudenberg helps them optimize cylinder components for hydraulic systems with the right sealing solutions. With the Perfect Cylinder program, the system efficiency of machines can be maximized without having to totally replace costly equipment. Freudenberg collaborates with its customers at the design stage and improves sealing systems for hydraulic cylinders while reducing material and production costs by up to 40 percent.

A sealing innovation is among the high-performance seals in the Perfect Cylinder program for heavy-duty vehicles: Guivex® guide bands. The profiled piston and rod guide bands are made of a new carbon-fiber-filled polyamide material. They are used in long-stroke-cylinder, short-stroke, short-guide-distance or high-side-load applications.

The size of the Guivex bands allows manufacturers to use them in radial load capacities that are 40 percent higher than standard guide bands, and they can be employed in all fluids normally found in hydraulic systems. The new Guivex bands can facilitate the reduction of cylinder gland widths and lengths, reducing costs. They also enable quieter operation. ©



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FREUDENBERG SEALING TECHNOLOGIES GMBH & CO. KG

ISOLDE GRABENAUER
+49 6201 80-7467
isolde.grabenauer@fst.com

ULRIKE REICH
+49 6201 80-5713
ulrike.reich@fst.com

COMPANY INFORMATION

PUBLISHER
FREUDENBERG SEALING TECHNOLOGIES GMBH & CO. KG
Corporate Communications
Höhnerweg 2–4, 69469 Weinheim

RESPONSIBILITY FOR CONTENT
Ulrike Reich (V. i. S. d. P.)

EDITOR-IN-CHIEF
Isolde Grabenauer

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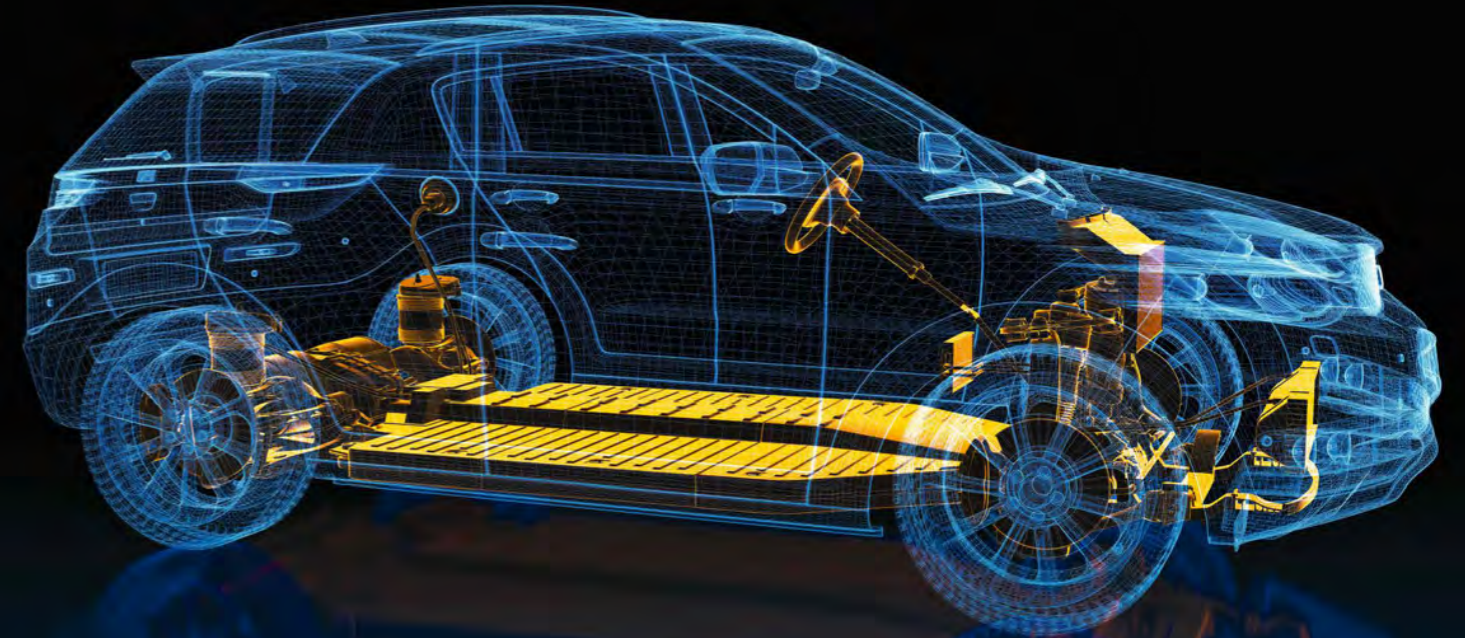
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