



MAKING THE RIGHT DECISIONS AT THE RIGHT TIME

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„KUKA has strong roots in Germany. And we will continue to grow from this base. We stand for Industrie 4.0 made in Germany. And that is what makes us successful worldwide.“

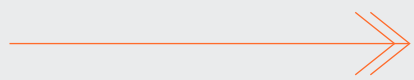
Dr. Till Reuter



Cover: The sensitive LBR iiwa supports humans in the smart factory.



MAKING THE RIGHT DECISIONS



AT THE RIGHT TIME

KUKA stands for Industrie 4.0 made in Germany and sets trends in robot-based automation. The increasing digitization of production and the cooperative networking of human workers and machines are set to change the world of work fundamentally.

KUKA moves in a dynamic, innovation-driven market environment, which is continuously being redefined. A key factor of success is making the right decisions at the right time in order to set the right strategic course. An important aspect of KUKA's success is the ability to identify and benefit from trends and opportunities early on, as well as having the courage to embrace change.





The sensitive LBR iiwa fetches components from a warehouse and learns from its experience.




Editorial



Dr. Till Reuter, Chief Executive Officer

Dear Shareholders,

With sales revenues of around 3 billion euro and an EBIT margin of 5.6 percent, KUKA can look back on a successful and also one of the most eventful years in the company's history.

Of course, you are well aware of this since you have experienced the media frenzy surrounding the acquisition of KUKA by Midea first-hand. You were at the center of events and had to decide whether to tender your shares or not. Now, Midea holds 94.55 percent of KUKA shares and has appointed four representatives to the Supervisory Board. Never before was KUKA exposed to so much publicity.

New technologies for Industrie 4.0 and digitization

At an early stage in 2016, our Industrie 4.0 endeavors got a big boost: KUKA robots performed during the opening ceremony of Hanover Fair and an LBR iiwa robot personally shook Barack Obama's and Angela Merkel's hand.

At our booth, we were able to enthuse our customers with solutions and concepts for the factory of tomorrow. In turn, the customers offered up ideas for further developments in this regard. We have the advantage of being well-versed in the various processes used in a wide range of different industries. This know-how benefits our customers in improving their own networked processes.

Individualized products at low production costs. This is a challenge that nearly every industry must contend with. But this can only be achieved with a smart, networked factory. Smart factories require an enormous data capacity to make system conditions and production scenarios predictable. Using big data efficiently will therefore play a key role. It becomes possible for complex production systems to be optimized when large amounts of data in a networked factory can be mapped and processed in real time. New production opportunities emerge when all of these conditions are met and industrial production is connected to the cloud and big data. >



With KUKA Connect, KUKA has developed a new cloud-based software platform that allows our customers to easily view the data of their KUKA robots from anywhere in the world and thus to increase the performance and effectiveness of their production operations. KUKA is implementing open global standards and offers customers a high-performance real-time computing platform in combination with big data analytics.

Robotics is also being shaped by this development. Robots are becoming more sensitive, mobile and can move autonomously. They are the link between the real world and the digital one.

We are boosting our innovative strength

KUKA is increasing its own innovative capacity by supplementing its know-how through start-ups and strategic partnerships. One of these start-ups is connyun. This company is developing a cloud-based platform that will enable KUKA to offer its customers an entire portfolio of services. We are

creating a new ecosystem around our customers. After all, our customers demand more than just information about the KUKA processes. They want to have an overview of the entire process, which is why connyun is also open to third parties. KUKA is ready to assist customers in implementing their smart factory.

Digitization has been a matter of course for KUKA employees for some time. They work in global, interdisciplinary teams and across various time zones. They are right at home in the KUKA Digital Business Cloud and communicate via an in-house business chat platform around the globe. This becomes evident to our customers when they venture into the KUKA product world via the digital marketplace.

Global strength with German DNA

As a company with German DNA that is firmly rooted at its headquarters in Augsburg, KUKA is a strong player on the European market. To achieve growth worldwide, it is critical to expand to locations all over the globe. Because the

„We have the advantage of being well-versed in the various processes used in a wide range of different industries.“

Dr. Till Reuter

Left: Dr. Till Reuter (born 1968) has been CEO of KUKA Aktiengesellschaft since 2009. Prior to that he worked as a lawyer and investment banker in Europe and the United States. In May 2008, he founded the holding company Rinvest AG, of which he is Supervisory Board Chairman.

Right: Peter Mohnen (born 1968) has been CFO of KUKA Aktiengesellschaft since 2012. Previously he was CFO at E.ON in Hungary, after having worked for many years in leading positions in accounting at E.ON in Essen.

robot density abroad is many times lower than in the highly automated European market. China is already the largest growth market worldwide.

In July, KUKA presented a tailor-made robot for the 3C market (computers, communications and consumer electronics) to an Asian audience at the China International Robot Show (CIROS) in Shanghai. In the Asian electronics industry, where production changeovers are frequent, it is decisive that the robots can be used flexibly. This is what prompted KUKA to develop the KR 3 AGILUS.

Midea, the new majority shareholder, supports this strategic approach and is smoothing the way. Particularly in terms of service and consumer robotics, Midea supplements our know-how and will enable us to access this new market.

Taking responsibility

New, innovative business models will also impact the value chain and how ownership is handled, as well as the role of robots. They will become increasingly important in people's daily lives. This raises questions in society: How do such developments change the world of work? Who is using what data? And how safe do technologies have to be? As a global automation company, KUKA has a responsibility to join the discussion and offer solutions. We are aware of this responsibility. Every day our employees give their very best to ensure a high level of safety and responsible use of data and process know-how.

While digitization may be changing many things, one thing remains the same: KUKA's success is based on the creativity and dedication of its employees and I would like to take this opportunity to express my exceptional gratitude to them.

Sincerely,



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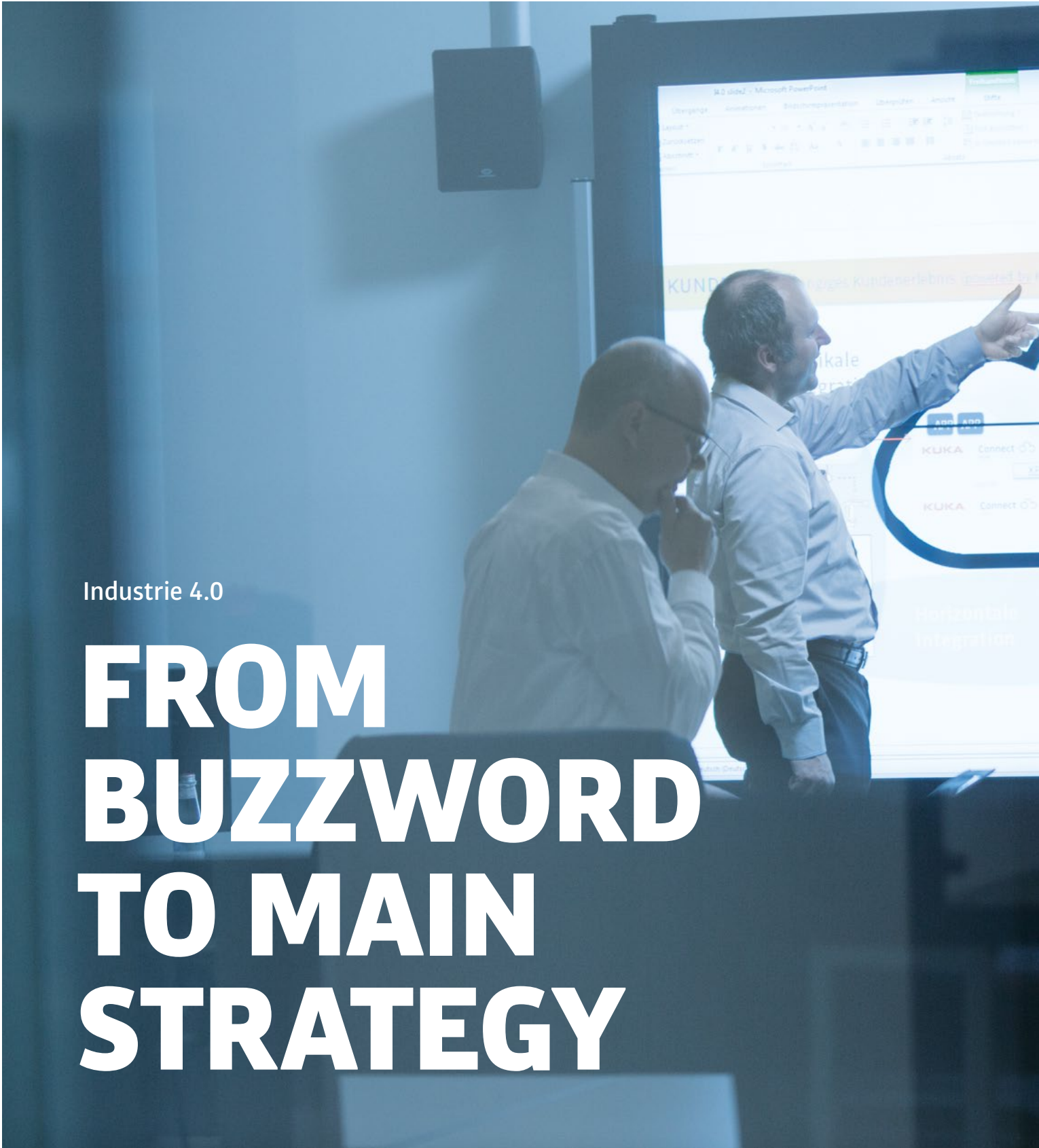
KUKA celebrates the inauguration of the Development and Technology Center in Augsburg

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Industrie 4.0

FROM BUZZWORD TO MAIN STRATEGY



At a time when the media were still debating whether Industrie 4.0 was a trend, a development or a revolution, KUKA had long recognized that digitization would change the world of production for good, and the company adapted its course accordingly.

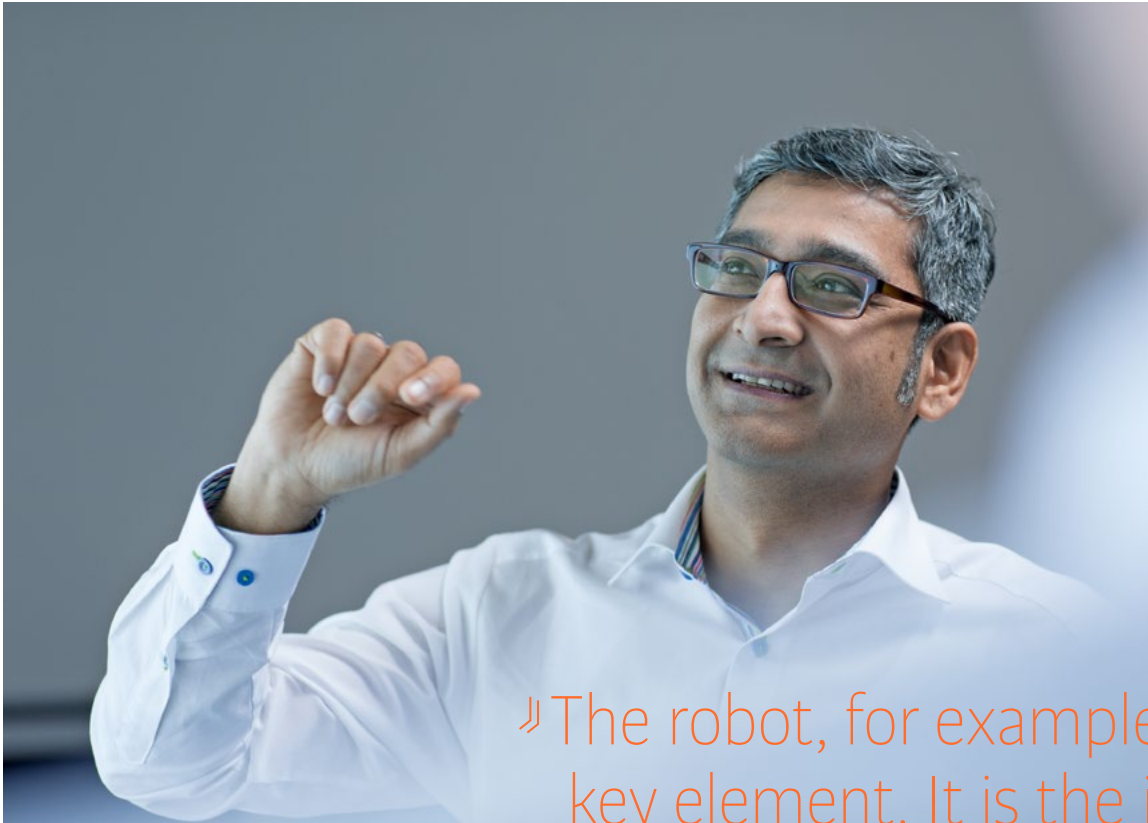


What people are familiar with from their private lives and their consumer behavior will sooner or later catch on in manufacturing as well. Customer needs will influence production and even control it. Today, people are accustomed to buying products online and having them delivered overnight. And at the same time they want the goods they order to be as individualized as possible. The color of the hip brand-name sneakers must be selectable or match the tracksuit. Individualism is “in” – made possible by the Internet. A lifestyle that places high demands on production.

Digitization and customer behavior will change entire manufacturing processes: in the future, production will be defined by cloud-based services. Manufacturing will be a service that can be ordered at the click of a button. The customer will buy a service rather than a system. We are familiar with similar concepts from car-sharing services or music streaming, for instance. This enables companies to offer the very flexibility that their customers demand. >

Focused on KUKA Cloud – Holger Ewald, Dr. Christian Schlögel and Rohitashwa Pant (left to right) discuss the optimal cloud solution for customers.

Rohitashwa Pant manages the team Industrie 4.0 Accelerator.



»The robot, for example, is a key element. It is the interface between IT and the manufacturing world.«

Rohitashwa Pant

“KUKA is at the core of this development,” explains Rohitashwa Pant, who is heading the Industrie 4.0 Accelerator team at KUKA. “The robot, for example, is a key element. It is the interface between IT and the manufacturing world. It collects data that can be used to improve processes.” Pant joined KUKA about a year ago to take on the challenge of fusing and promoting all Industrie 4.0 projects within the company.

“Previously, I was working at a consulting firm that dealt with Industrie 4.0. Such an opportunity to translate the conceptual framework of Industrie 4.0 into real projects and work at the forefront of innovation comes around once in a lifetime,” explains Pant. He started his career at Siemens in Erlangen as a commissioning technician for automation systems. After working in the United States and India, Pant

focused increasingly on digitization and most recently worked at Accenture Digital in Munich. “Bavaria is home to me, but so is India. Originally I’m from Mumbai, but my children were born in Munich,” says the young father about his son and twin daughters. “I’m happy here.”

Pant is now working on the conceptual implementation of Industrie 4.0 at automation specialist KUKA in Augsburg. “At KUKA, we are attempting to demystify this abstract concept on a daily basis.” Among other things, the team is examining how to better organize complex and opaque processes through networking. The team is also working on the issue of analyzing the production environment and

adapting processes accordingly by using digitization. “Such an approach is feasible today, because now we have the appropriate technologies and sensors to attune dynamic parameters, such as the temperature or power consumption, to the production process centrally in the cloud,” states Pant. “Industrie 4.0 thus helps us build intelligent solutions, so that we can flexibly adapt to different circumstances.”

But Industrie 4.0 is much more than just a project. The entire company is undergoing a transformation on account of Industrie 4.0. "In the digital world, everything is connected. Global IT is therefore geared fully towards this transformation," says Chief Information Officer (CIO) Holger Ewald in explanation of the latest strategic course adjustments at KUKA. Within the large-scale Power ON program, important groundwork is being laid for Industrie 4.0, for example in the form of globally harmonized processes and product data. "Building upon this, we are digitally connecting goods, information and financial flows with the KUKA Digital Business Cloud. This means that, in the future, we will have a common digital language within

KUKA and towards customers." For customers, this change will be noticeable as soon as they access the digital KUKA marketplace. The website at <https://shop.kuka.com> is not only about purchasing new KUKA products, it also offers user manuals, training videos and any other information the customer may need. >

Holger Ewald,
Chief Information Officer (CIO)



„In the digital world, everything is connected. Global IT is therefore geared fully towards this transformation.“

Holger Ewald



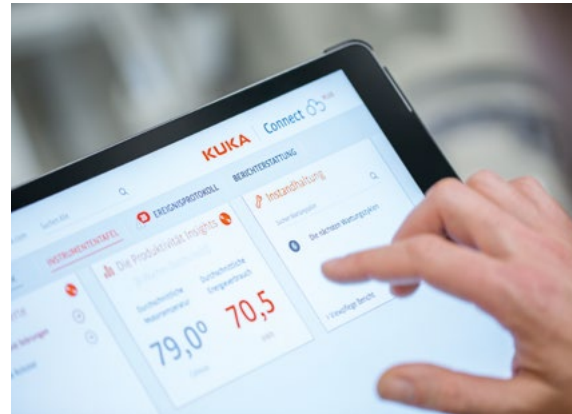
“As the KUKA product range continues to grow, a digital trading platform is vital in order to provide customers with an intuitive experience and a comprehensive overview of new products,” emphasizes David Fuller, Head of Research and Development at KUKA Robotics. With a focus on digital business transformation, the KUKA marketplace offers customers the newest zero touch IoT solution from KUKA for intelligent production: KUKA Connect. Fuller

is particularly proud of this product. It allows customers to access robot data in their production operations – in a convenient manner on a computer and no matter where the robot is located. The robot informs the customer when it is due for maintenance or provides information about its energy consumption.

KUKA Connect is a cloud-based product that enables customers to make their production more efficient, to boost output and above all to be more innovative. KUKA is implementing open global standards and makes use of large-scale data analytics and a fog computing platform in order to offer customers maximum transparency with regard to their robots. >

»As the KUKA product range continues to grow, a digital trading platform is vital.«

David Fuller



KUKA Connect allows customers to access robot data in their production operations.

David Fuller,
CTO KUKA Roboter GmbH



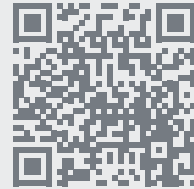
Intelligent production: the robot communicates with the intelligent coffee machine and exchanges data with the cloud. The system data can be accessed from anywhere using a mobile device.



Hanover Fair
2016

COFFEE 4.0 – THE ROBOT BARISTA

Order your customized cup of coffee by smartphone and have it served by a robot soon after: this is now possible thanks to the Internet of Things. Two KR AGILUS robots operate one coffee machine each, receiving the required data from the cloud. In line with the Industrie 4.0 philosophy, the process is not controlled by a central entity. The cups, which are provided with a QR code, move autonomously through the decentralized production system. Status messages are sent to the smartphone during the production process. <



SMART FACTORY

Networking production components to create an intelligent system: mobile robots for transport, automated warehouse systems, robots for quality inspection, sensitive robots to collaborate with humans – all components of the Smart Factory are capable of communicating with each other and exchanging information about the respective order status. The Asset Management feature in the KUKA Cloud offers users a clear overview on their smartphone. <



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Hanover Fair
2016

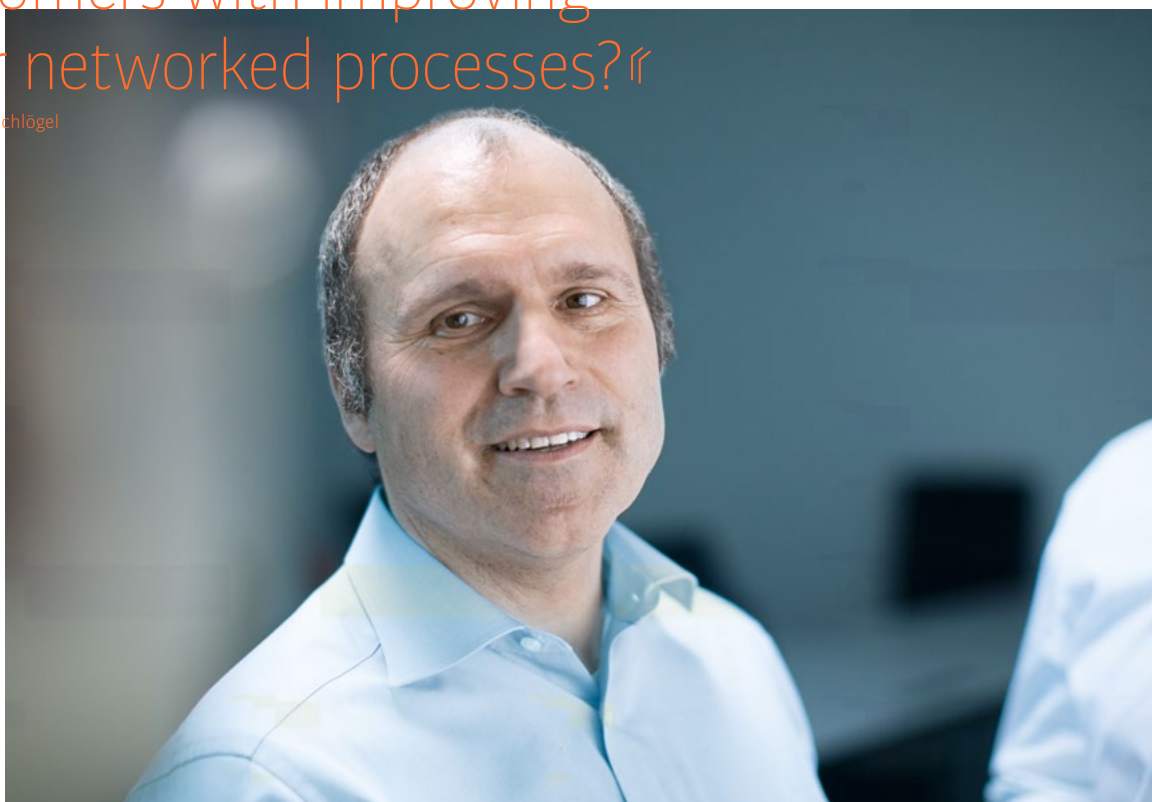
Trade fair visitors had individual protective covers made for their smartphone in the Smart Factory.



»If not us, then who will assist customers with improving their networked processes?«



Dr. Christian Schlögel



Dr. Christian Schlögel,
Chief Technology Officer
(CTO) of KUKA Group

“It is very advantageous to KUKA that we possess so much process know-how,” explains Christian Schlögel, Chief Technology Officer (CTO) at KUKA. “If not us, then who will assist customers with improving their networked processes?” Networking and collecting data is one thing, but making use of the data is an entirely different matter.

Schlögel is also CEO of connyun, a start-up company that is developing the cloud-based platform via which KUKA will offer its customers a whole ecosystem of services, and which also provides the underlying technical foundation for KUKA Connect.

“We anticipate that our customers will want more than just information about the KUKA processes. They will only be able to optimize their processes once they have an integrated understanding, from the robot to the gripper and through to the environment in which the robot is deployed.” This is why Schlögel wants to open the connyun platform to third parties as well. “After all, the motto is ecosystem rather than egosystem,” he explains, giving a smile. “Those who hoard all processes and data for themselves will not last very long in a competitive international marketplace.” Sharing is a key factor in the digital transformation. This

does not mean, though, that just anyone will have access to the data. “The customer will decide who and why someone is allowed to view the data.”

But the KUKA engineers are in agreement that a rethink will be required. It is crucial to be prepared for the digital transformation. And this transformation starts with the KUKA employees themselves. They have long become accustomed to interdisciplinary approaches. They work in global teams and have no problem coordinating between different time zones. For example, a development team in Austin provides the IoT know-how. The employees are supported in their interdisciplinary exchange of information by the KUKA Digital Business Cloud. In this social business network by the name of Chatter, employees share knowledge, discuss current issues and organize into project groups. Since June, Chatter has been an integral part of the workplace at KUKA worldwide – a digital collaboration across borders. <



Essay

THE FUTURE WILL BE WHAT WE MAKE OF IT

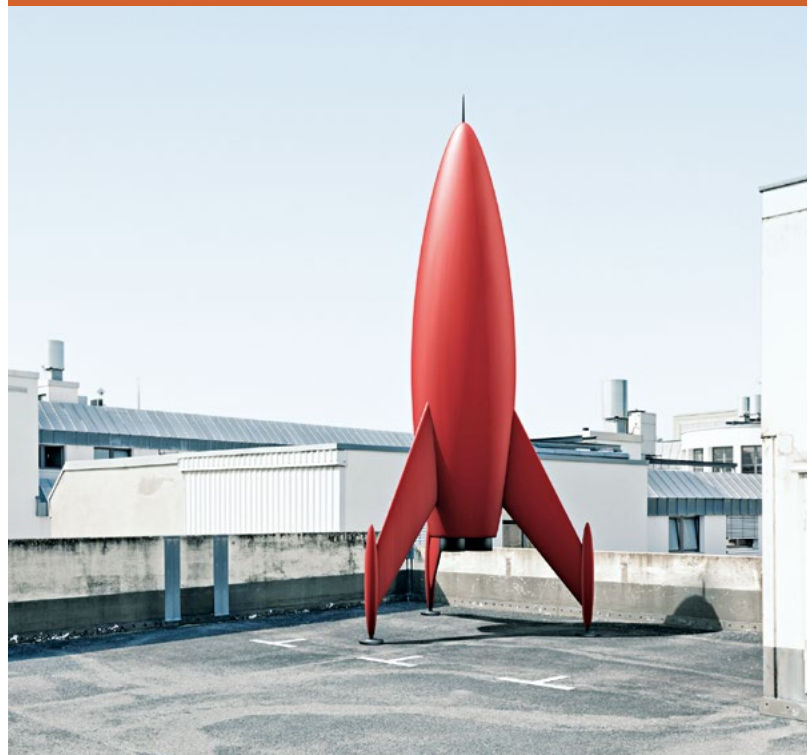
We make approximately 20,000 decisions every day, many of which are taken unconsciously within a split second. If they are decisions in companies, it is important to take a little more time – and to consider the major trends in society.



The economist Hariolf Grupp, who used to be a futurologist at Fraunhofer ISI and father of the forecasting method Delphi, once said: “If our predictions are correct, we have done something wrong.” Grupp visibly enjoyed irritating his listeners. Is it not the task of a futurologist to see exactly what is going to happen in his crystal ball? No, contradicted Grupp, it is about formulating scenarios and options for action. The essence of his perspective: the future is not a straight arrow with a defined direction, it is a space of possibilities including futures which need to be prevented, even though they seem very probable at the time.

The number of computers required worldwide, the triumph of fuel cell vehicles, or artificial intelligence which makes people redundant: the list of failed predictions is incredibly long. Astrologers, fortune tellers and the oracle of Delphi have known this for thousands of years and therefore consciously make their premonitions vague so that everything is somehow always right. Market research institutions, on the other hand, prefer mathematical methods and surveys – often with modest results. >

Is it not the task of a futurologist to see exactly what is going to happen in his crystal ball?





Megatrends such as demographic changes or customization must be taken into account in order to set companies on a successful long-term course.

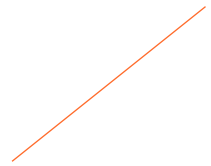
Why do we like to believe in predictions, even though we know that they almost never come true? The assumption is that the future scares us, we somehow want to make it more predictable and set it in stone. The little brother of forecasting is planning. It is based on the assumption that if we were able to predict the future, certain measures must necessarily take us there. However, detractors claim that planning is only replacing coincidence with error.

If you have read up to this point, you may ask yourself how there is any room for such an ostensibly pessimistic perspective in the annual report of a forward-looking company like KUKA? If a forecast doesn't work and planning is pointless – what happens next? The good news is: a good strategy and good planning are very important, but not in the sense of a checklist which needs to be worked through. An innovative company also develops options for action in future scenarios which are not very likely, but are all the more exciting. Or expressing it another way: those who cannot predict the future, should shape it. Those who show great courage can also focus on the strategy of creative destruction which American authors are especially enthused about. Every company needs to find the happy medium between “keeping it up” and “upsetting the applecart”.

But how? Here are a few thoughts on how companies can shape the future:



Digitization and the inexpensive availability of ever greater computing power make it possible: storing, sharing and interpreting millions of records and their subsequent evaluation.



The megatrends as guidelines

Global warming, demographic change, population growth, urbanization, digitization – there are developments which you can rely on. These megatrends must be taken into consideration along with other industry trends. Every (really every!) company will be faced with these topics sooner or later. Trends that are evident in robotics are digitization, demographic change and the resulting shortage of skilled labor. A trend with far-reaching consequences is individualization. People are increasingly living alone and the workplace and colleagues are replacing their families in establishing a sense of purpose in their lives. Work 4.0 must convey this sense. The robotics industry is working on a change of image in this context: it is moving away from the heavyweight behind fences that makes human work less onerous, but also partially redundant, to a sensitive partner that takes tedious tasks off factory workers' hands and gives them back their autonomy. The value of work is increasingly measured in terms of appreciation, including our own appreciation. If we think this through properly, it means that we also have to appreciate people when they are not working.

Nothing can be taken for granted

But what happens to people who can't keep up with the pace of technological development? A better education is what's needed, say all politicians in unison. Germany is well-equipped with its education system, especially with the dual education copied worldwide. However, there is still room for improvement, particularly when it comes to dealing with technology as a matter of course. This is where emerging countries have a great opportunity. The people in these countries do not carry a burden of concerns, they are inquisitive and hungry for technology. This encourages the opportunity to share economic success and promotes curiosity about products made in Germany – everybody benefits from it.

However, it is important to be cautious with growth forecasts. Five years ago, all economists had Russia, Brazil and China at the top of their list, but they have fallen short of many expectations. That is likely to change again, but it is not something you can rely on. Further economic growth through private consumption is also an uncertain hope. A third car, a television in the bathroom? It is something you can have, but it is not a necessity. Trends such as the sharing economy may gain momentum: using instead of owning. Operator models are becoming more and more important in mechanical engineering and robotics and the pace is picking up further with digitization (see above).

Customers are an inspiration – but not just that

German industry prides itself on being especially close to its customers and their applications. But when you ask customers what they expect from a new product, the answer is often the following: it should do the same, but be quicker and cheaper. That is incremental innovation and is not a bad thing. However, this is not enough for a high-tech company. This type of company innovates in fields which the customer does not yet give a moment's thought. Does a worker need a small robot arm that hands over parts? Maybe not. He has done without one so far. Yet, KUKA developed the lightweight robot iiwa anyway. It represents a bet on the future, but a bet with very good odds.

Staying power is called for

The lightweight robot iiwa again: robot researchers like Martin Hägele (see interview on page 22) already had predecessor models in their laboratories years ago. At the time, the unwieldy arms which, like small children, refused to do what their flesh-and-blood partners wanted, were still ridiculed. Nobody is laughing any more.

Finding the right partner

When is a partner the right one? When he or she doesn't say yes and amen to everything. Otherwise, you could also do it yourself. The step from the "not invented here" barrier to "open innovation" is painful for many traditional industrial companies, but necessary. Caution is required, however: it is important to protect know-how, especially in high-tech industries. Some people consider there to be a risk, especially through Industrie 4.0 and the Cloud. See what digitization expert Michael Suppa has to say (see interview on page 28).

Culture is everything

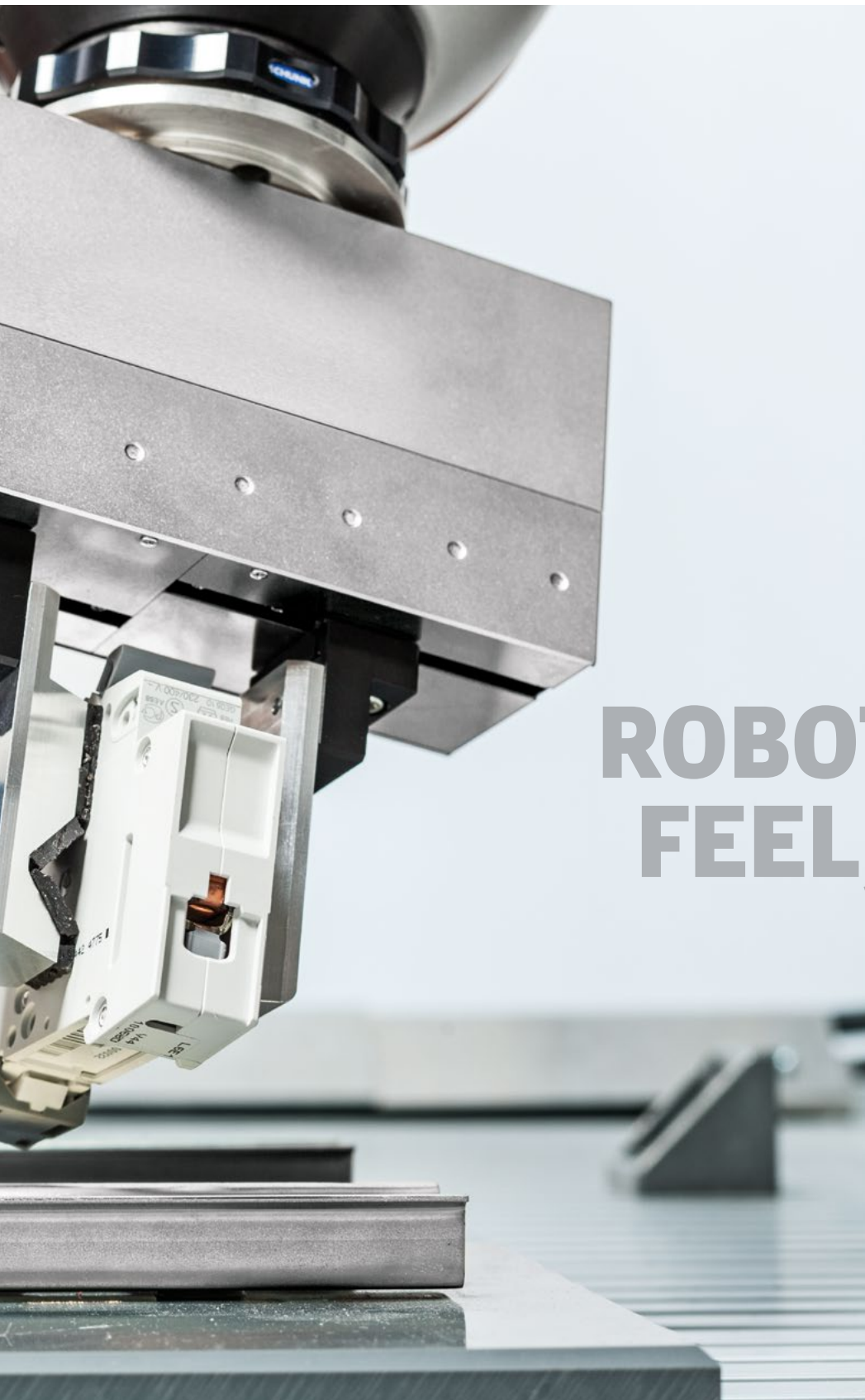
The most important message is a platitude, but many companies have a hard time with it – fortunately this does not include the family-oriented German mechanical engineering industry: a company is not an abstract thing, but is only as valuable as the amount of energy and know-how its own employees and partners invest in it. The key concept is corporate culture. It forms the basis for a culture of innovation, which in turn requires an error culture. This is reminiscent of Charles Darwin's theory of evolution. It is not about who is the fittest as some people wrongly assume, but rather who is the most adaptable. Adaptation is accomplished in evolution through change and selection, you could also say: trial and error. Companies cannot be as wasteful as nature. They cannot leave everything to chance. But they can keep moving, conquer new fields of technology and initiate partnerships. Only those who keep moving survive.

"The future used to be better too," joked Bavarian comedian Karl Valentin. That is illogical in that what used to be the future is of course now our present. And that isn't all that bad either. That gives us hope for tomorrow's future. It is up to us to be courageous in building it. <

» The key concept is corporate culture. It forms the basis for a culture of innovation.«

The Robot and Assistive Systems department of the Fraunhofer Institute for Manufacturing Engineering and Automation (IPA) develops new key components and technologies for future robot applications and complete robotic systems.





Trends in robotics

ROBOTICS 4.0: FEEL, LEARN, ASSIST

Interview with Martin Hägele,
head of the Robot and Assistive
Systems department and the area
of Intelligent Automation and
Cleanliness Technology at the
Fraunhofer IPA, Stuttgart

Martin Hägele has been working on robotics topics at the Fraunhofer IPA for more than 25 years.



Robots without fences, working together with humans and intuitive to operate – this vision has now become a reality, according to Martin Hägele. In this interview, the researcher from the Fraunhofer Institute reveals what other applications robotics will soon tap into. Together with Industrie 4.0, this will also enable new business models.



Mr. Hägele, you have been working on robotics at the Fraunhofer Institute for more than 25 years. Looking back, what were the most important trends?

Hägele: There are four trends in particular which have emerged over the last 20 years: PC technology has become part of robotics, also sensor technology, particularly image processing, and of course enormous strides have been made in terms of performance, precision and technical reliability. One of my personal highlights, which I have been actively involved in from the beginning: the advent of service robotics has resulted in some exciting applications for robots outside of production, too.

And what hopes and expectations have not come true?

Hägele: For this span of time, three examples spring to mind: direct drives, which were pushed at one point, were unable to get any traction, industrial robots are still made predominantly of metal and not plastic, and some fields of application have been much more reluctant to use robots than expected, for example, food production, construction and even industrial assembly.

Would you nevertheless venture a forecast for the coming years?

Hägele: Some trends are easy to spot: first and foremost the incorporation of robotics in Industrie 4.0 infrastructures, the use of robots in production with small batches, and the further elimination of safety fencing. One of the prerequisites for this is the use of more sophisticated sensors that are capable of detecting objects and surroundings, or determining forces to be applied. A current milestone in this regard is the lightweight robot iiwa, which is breaking new ground with its ability to assemble safely and sensitively. The next step involves learning systems which are able to improve their performance from experience, for example when detecting objects or for optimized process control.

Let's stay with Industrie 4.0: why is this so closely linked to robotics?

Hägele: Robots are prime examples of cyber-physical systems: equipped with powerful controllers, sensors and user interfaces and capable of networking. Cost-effectiveness and flexibility depend on their ability to semi- or fully-automatically generate and adapt their programs. This requires the availability of current product and process data to the robot. Furthermore, the volume of data captured during ongoing processes forms the basis for new services. Data analytics yields new findings, which in turn can be translated into new services and business models.

Which new business models is robotics able to tap into?

Hägele: I can see two important directions. Firstly, the industry has been discussing new financing and operator models for robots for some time. KUKA was a leader in this regard with its plant in Toledo, for example, where the bodies for the Jeep Wrangler from Fiat Chrysler are manufactured under KUKA's own responsibility. Or versatile production plants, which lease additional robots temporarily during capacity bottlenecks or sell robot time to other manufacturers during periods of overcapacity. Another direction comprises services or skills to improve the utilization of robots. Predictive maintenance is one of the most frequently cited examples of this. But robot manufacturers could also offer software and platform services with interesting options comparable to smartphones, whose functions can be expanded with apps and services. >



„According to estimates, there are already about 1,000 robots worldwide working collaboratively, meaning they share tasks with humans.“

Martin Hägele

You mentioned human-robot collaboration as another trend. We have been hearing a lot about this. To what extent is it actually implemented?

Hägele: According to estimates, there are already about 1,000 robots worldwide working collaboratively, meaning they share tasks with humans. Collaborative robots present workpieces, perform assembly or machining tasks together with the human operator, or they serve as strength boosters: the robot carries the load, while the person guides it.

Those numbers don't sound very high yet...

Hägele: They will be steadily increasing, especially in the field of what is known as human-robot coexistence. The vision is a world without fences around robots. At first, though, this makes the system more challenging in the planning and deployment process. This is why we are working on simplifying the planning processes by supporting the planning of robot applications with IT tools and even automating it in some cases. Another big topic is the intuitive setup or programming of robot systems: this is achieved using dialog systems, for example, which integrate graphic programming, tactile guidance and, in the future, speech

recognition. It allows the robot to learn the intentions of the human operator over time, making the collaboration more intuitive for the worker.

So humans are not becoming dispensable, as many are fearing?

Hägele: On the contrary. Robots need humans. And humans need robots, because robots can take on ergonomically stressful tasks and activities that are mindlessly repetitive. But when it comes to the combination of experience, dexterity and assessing situations, robots are nowhere close to the abilities of humans. Apart from that, the level of acceptance of collaborative robots is very high among workers, as long as they are involved in the planning phase and are given adequate training.

What companies will play a leading role in robotics in the future?

Hägele: Innovative market leaders such as KUKA will most certainly be at the head of the field. In addition to that, a very dynamic start-up culture has emerged. In service robotics alone, there are more than 600 companies worldwide that are developing interesting products and solutions for a vast variety of commercial or private applications. An estimated 200 or more of those companies are considered start-ups, meaning they are no more than five years old. These companies are heavily driven by technology and are conquering new markets such as in the healthcare industry or agriculture. New market participants in robotics are emerging, such as Internet providers or online retailers who buy robots and combine them with new business models, e.g. in logistics or customer service.

Does that mean that robots are also tapping into applications outside of factories?

Hägele: Service robotics is a big market with double-digit annual growth. In the commercial sector, the current global turnover is 4.6 billion dollars. But the market is growing rapidly in the private sector, too. We already have lawnmowers, vacuum cleaners and window cleaners. Next in line are multimedia butlers for the home.

And when will robots be capable of loading the dishwasher or picking up items off the floor?

Hägele: Many of today's robots only fulfill a specific purpose, and they have no arms to perform any such useful handling tasks. But this will change. Interacting with robot assistants will become a matter of course. <



Martin Hägele studied Mechanical Engineering and Engineering Science in Stuttgart and in Washington DC. He has been at the Fraunhofer Institute for Manufacturing Engineering and Automation (IPA) in Stuttgart since 1989, has headed the Robot and Assistive Systems department since 1993, and the area of Intelligent Automation and Cleanliness Technology since 2016. Martin Hägele has been recognized with numerous awards, including the JosephEngelberger Award in 2007, the robotics industry's highest international honor.



The test facility of the Robotics department



Trends in digitization

SMART NET- WORKING

Interview with Dr. Michael Suppa,
CEO of the start-up
Roboception GmbH, Munich

Digitization, cloud, big data: these are issues very much on people's minds in the automation industry, too. Michael Suppa, CEO of Roboception GmbH, has a word of caution.

E **Everybody is talking about Industrie 4.0. Is the automation industry adequately prepared for this?**

Suppa: Automation and especially robotics is traditionally an engineering matter in Germany, since much pertains to kinematics and mechatronics. Industrie 4.0, on the other hand, largely involves interfacing to other fields. Manufacturers must evolve from mere product suppliers to complete system suppliers, as KUKA for example has been doing for some time.

The automotive industry anticipates that digital services for operating a car will one day account for a larger share of value creation than the actual construction of the vehicle. Will the same be true for robotics?

Suppa: That is my firm conviction. We can already see today that the actual robots are getting cheaper. At the same time, customers expect their robots to be far more useful and flexible than they have been, i.e. they want them to be "smarter". Services, updates, new capabilities via software: this is where the profit margin of the future lies. That is why we at Roboception are working to tap into these markets. >

„While in the past people were under the illusion that robots would become intelligent in the sense of human intelligence, today it is rather about making robots more flexible as tools, for example in collaboration with humans.“

Dr. Michael Suppa



What role will big data and artificial intelligence play for robotics in the future?

Suppa: We must make some distinctions here. If we are talking about only the robot, per se, then I don't think big data is the right term. After all, the data volume in robotics is generally not very large. Big data comes into play when several machines and a really large amount of process data are networked.

I don't think the term "artificial intelligence" is appropriate either. I would rather refer to this as machine learning, although the focus here has shifted over the last 20 years. While in the past people were under the illusion that robots would become intelligent in the sense of human intelligence, today it is rather about making robots more flexible as tools, for example in collaboration with humans. Roboception's

solutions allow robots to perceive their environment so that they are capable of accomplishing these tasks. With this in mind, it is not about replacing people in factories, but rather about supporting them.

How will that impact value creation processes and what new business models will evolve as a result?

Suppa: Today, robot manufacturers sell their products to integrators or they integrate them into systems themselves, such as those from KUKA Systems. More flexible robots would facilitate the integrator's task, while the manufacturer of the robot could demand a higher price. It is also conceivable that entirely new business models will be offered to end customers.

If digitization and the cloud are becoming increasingly important, wouldn't this mean that IT companies will enter the fray of mechanical engineering and robotics?

Suppa: These companies are already doing that today. While this is practical for the user, the consequences must be considered. After all, these corporations are basically huge learning factories that exploit these data. This is how an online mail-order business knows that you need coffee right after you ordered a coffee machine, and it makes you an appropriate offer. By utilizing their knowledge, these companies could make robots more adaptable and capable of learning, from which users would benefit. However, what they are lacking is the process know-how of mechanical engineering firms, who know exactly what a robot needs to



Dr. Michael Suppa in conversation with Elena Gambaro, a software developer advancing innovative techniques for 3D object recognition.



Dr. Michael Suppa is CEO of Roboception GmbH and is responsible for strategic development. Roboception develops software products offering real-time perception and manipulation solutions for robot systems. Previously, the electrical engineer had worked at the German Aerospace Center, researching the visual perception of robots.

do in order to move a sheet metal panel from A to B. They are familiar with their customers' problems and know how to solve them reliably. It is crucial to protect this exclusive knowledge. We at Roboception attach a great deal of importance to keeping our customers' data safe.

And how is this achieved?

Suppa: Machine and system builders must take a close look at what knowledge is contained in their data and consider carefully which data they choose to share. They must develop an understanding of what can be done with their data. To do so, the companies must build up their data competences without neglecting the mechatronic aspect.

How important is the issue of cyber security?

Suppa: It is extremely important and challenging. Industrie 4.0 is founded precisely upon the many networked components and interfaces. Of course, this openness allows others with less honorable intentions access, too. This must be kept in mind, and hardware and software solutions must be developed and deployed which restrict access to sensitive data to appropriately authorized users and systems.

If digital services are becoming more important in mechanical engineering and robotics, are universities and industrial training establishments still conveying the proper skills?

Suppa: Today, it is no longer feasible for an electrical engineer to be completely uninformed about software. Robotics – along with many other industries – is at the crossroads of mechanical engineering, electrical engineering and information technology. That is how it should be taught at universities, but unfortunately this is not always the case. Industrie 4.0 is more comprehensive, you could even say more holistic, than the previous industrial revolutions. The steam engine had a selective impact, whereas digitization encompasses all areas of life. To keep pace with this, it is important to encourage and qualify people, because everyone is affected by digitization in a networked world. <

Very Important Robots 2016

HOW KUKA ROBOTS BECAME VIRs

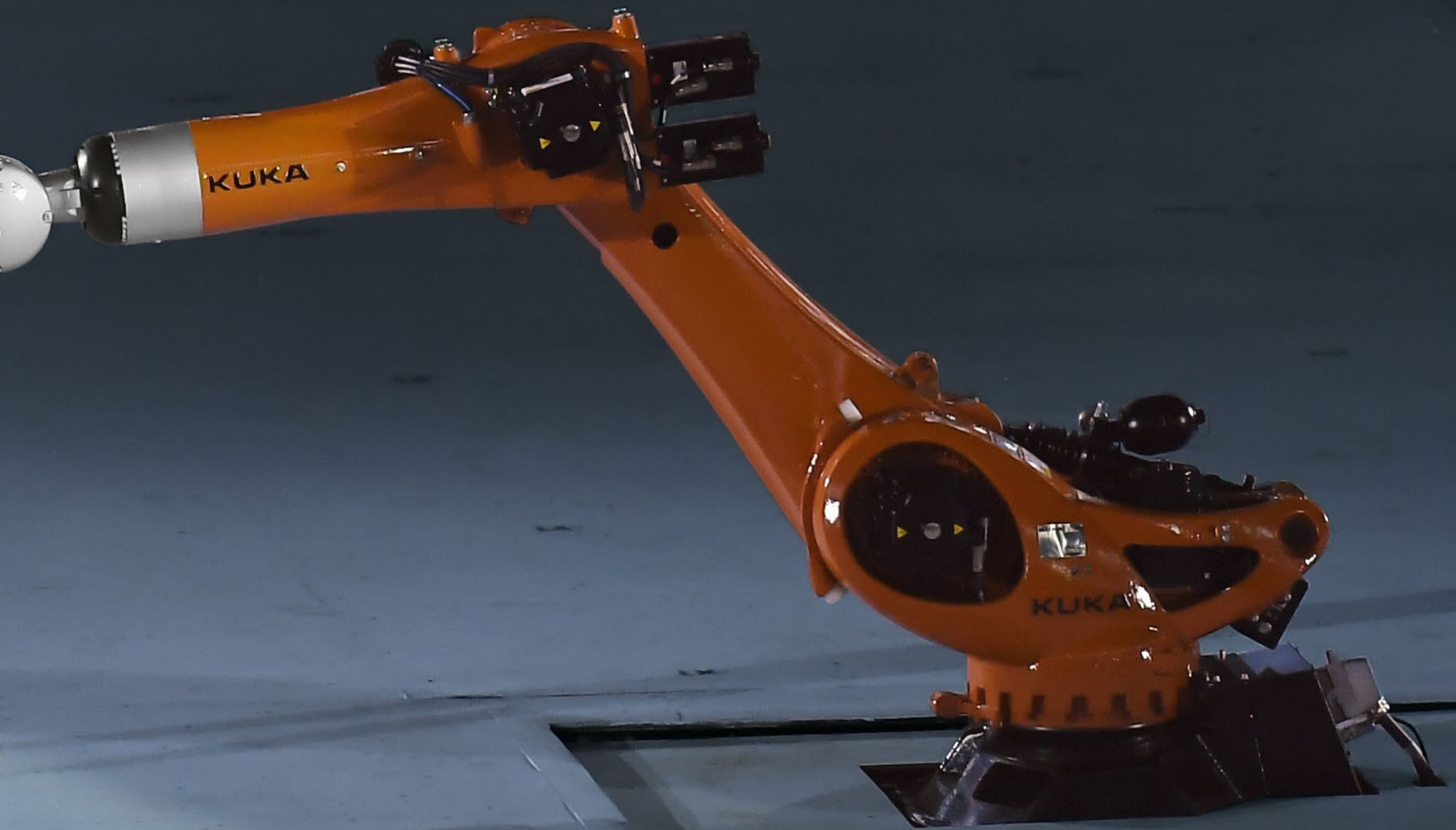


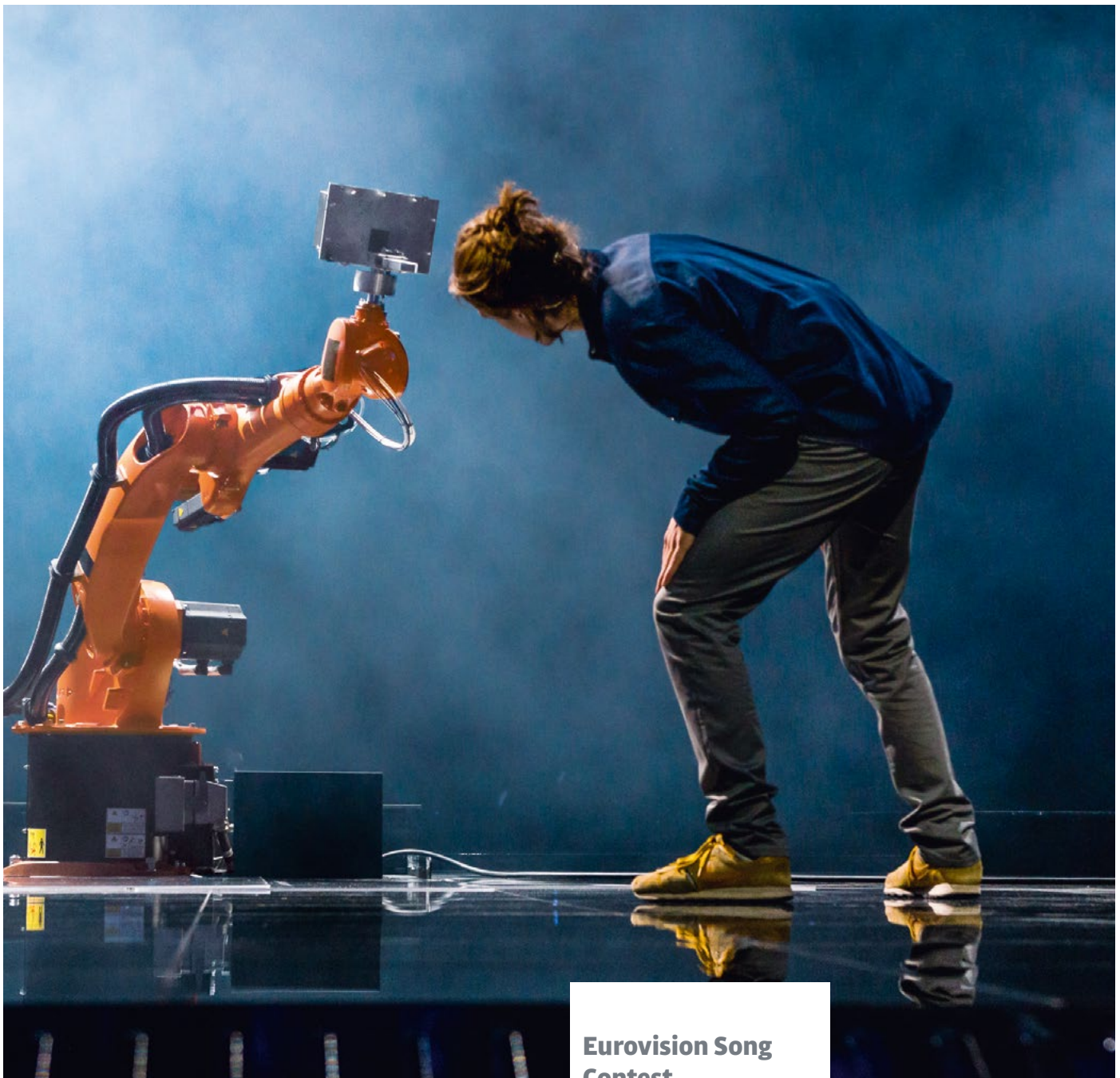
They have numerous talents, always perform at the highest level and are real eye-catchers. No wonder KUKA robots are in demand worldwide – even for the most unusual jobs.



Paralympic Summer Games

This spectacular show will certainly be remembered for a long time to come. At the opening ceremony of the 15th Paralympic Summer Games in Rio, a KR QUANTEC danced with US athlete Amy Purdy to the music of Brazil's Sérgio Mendes – a very special occasion.





Eurovision Song Contest



In the second semi-final of the Eurovision Song Contest, an unusual dance ensemble caused great excitement. Three robots of the KR QUANTEC series teamed up with three human dancers to entertain the audience with an impressive performance.





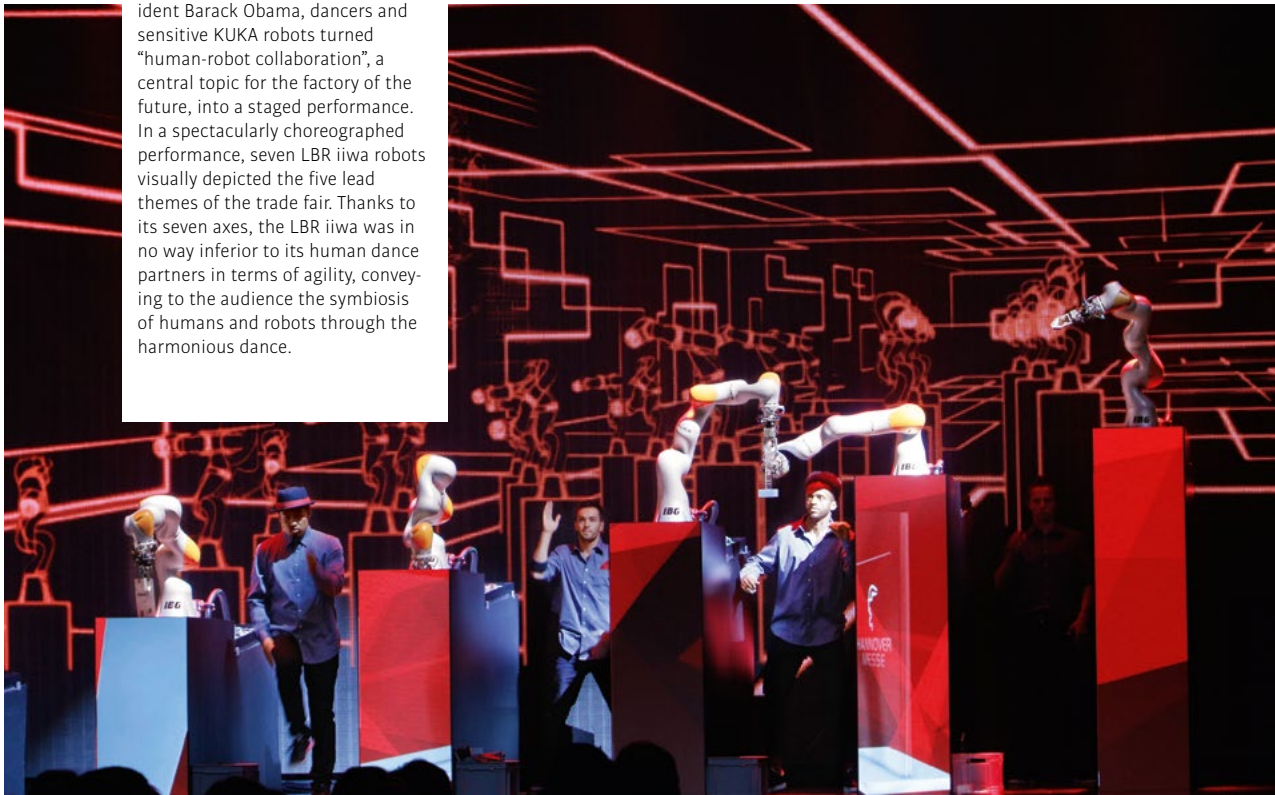
Olympic Games in Rio

On this occasion, it was not a robot but KUKA's brand ambassador Timo Boll who took center stage. At the opening ceremony of the Olympic Games in Rio, the table tennis pro carried the German flag into the legendary Maracana stadium, leading the German Olympic team. He had received the most votes from fans and athletes.



Opening of Hanover Fair

A human-machine choreography impressed at the opening ceremony of Hanover Fair. In front of some 3,000 guests including Chancellor Angela Merkel and former US President Barack Obama, dancers and sensitive KUKA robots turned "human-robot collaboration", a central topic for the factory of the future, into a staged performance. In a spectacularly choreographed performance, seven LBR iiwa robots visually depicted the five lead themes of the trade fair. Thanks to its seven axes, the LBR iiwa was in no way inferior to its human dance partners in terms of agility, conveying to the audience the symbiosis of humans and robots through the harmonious dance.

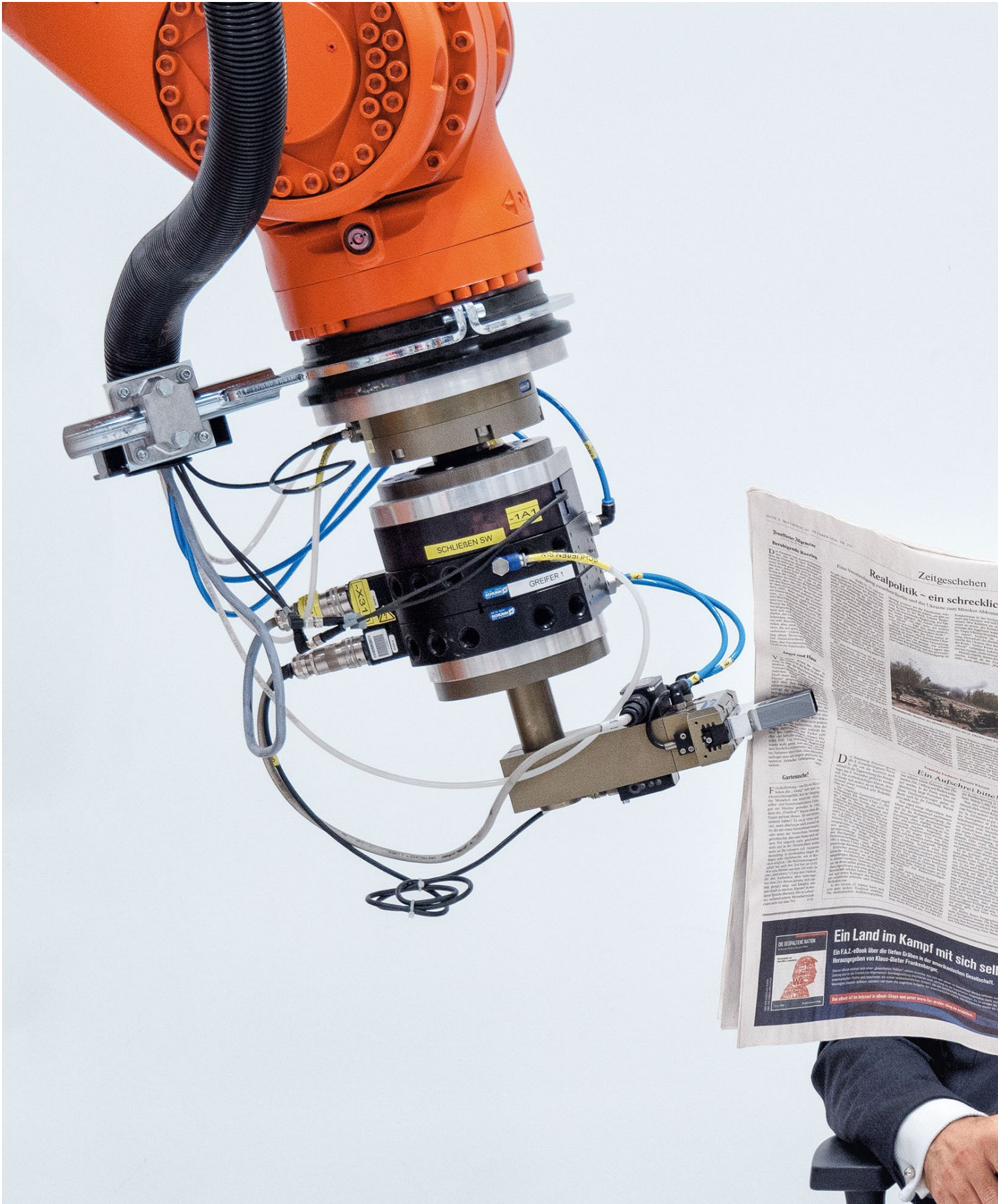




Hanover Fair

Not many can claim that they shook hands with Barack Obama and Angela Merkel. The LBR iiwa had this honor at Hanover Fair. At the Weidmüller booth, Dr. Till Reuter, CEO of KUKA AG, introduced the sensitive KUKA robot to the heads of state.

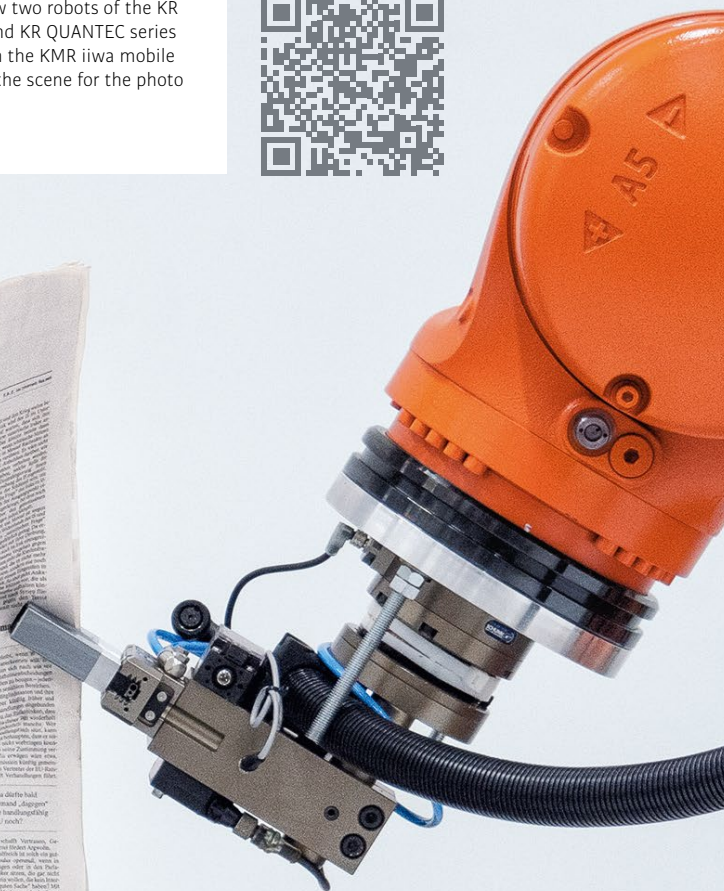
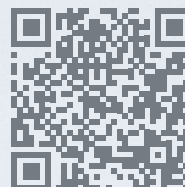




“FAZ” campaign

When CEO Dr. Till Reuter was photographed for the well-known campaign of the Frankfurter Allgemeine newspaper – “There is always a bright mind behind it” – robots naturally played a supporting role.

The entertaining making-of film shows how two robots of the KR FORTEC and KR QUANTEC series along with the KMR iiwa mobile robot set the scene for the photo session.



英基

TOWARDS THE EAST

Why KUKA is focusing on the Middle Kingdom

Rising wages, an aging society and higher demands on quality and flexibility are changing the manufacturing industry in China. More efficient and less physically strenuous production methods are increasingly being sought.

Many processes are not automated yet, which is why robots are in high demand, making this huge country an attractive market.

» Today, KUKA generates sales revenues of around €450 million in the People's Republic, with the goal of reaching the one billion euro mark there by 2020.«



The Middle Kingdom is getting ready for the future: virtually no other automation market has developed as dynamically as China over the last few years. According to the latest data from the International Federation of Robotics (IFR), China was the world's largest market in 2015 with approximately 68,600 industrial robots sold. This means the number of units sold increased by 20 percent over the previous year and exceeded the sales volume of all European markets combined (50,100 units).

The enormous potential in China is laid bare in a comparison with highly automated industrial countries: according to the IFR report, the density of robots across all manufacturing sectors in 2015 was 531 robot units per 10,000 employees in South Korea, which came out on top, and 301 units in Germany. The figure for China, on the other hand, was a mere 49 units, but with a strong upward trend.

And the ambitions of the Chinese are big: the People's Republic aims to pull even with modern industrial states, and it is using digitization to do so. "Manufacturing must become smarter, and it must be built upon technologies such as the Internet, cloud computing and big data," said China's Premier Li Keqiang during the 2016 World Economic Forum in Tianjin. The program "Made in China 2025", which was adopted in 2015, is intended to transform the People's Republic into a modern, innovative industrial power. Germany is an important technology partner in this undertaking.

For automation specialists such as KUKA, China is one of the most important growth markets. This is an aspect that is also anchored in the corporate strategy. Today, KUKA generates sales revenues of around €450 million in the People's Republic, with the goal of reaching the one billion euro mark there by 2020.



KUKA has a positive image in China and an edge with technology "made in Germany". The aim is for this positive perception to be further expanded in the years to come. Even after the acquisition by the Chinese group Midea, KUKA remains a company with German DNA and a German research location, though with top growth opportunities in China.

KUKA's new owner supports the growth strategy and will open the doors to China even wider. Particular standout opportunities are presented by such areas as service robotics and the electronics industry with its short life cycles and individual requirements. But to be successful in Asia, companies need to be on site in order to understand the market and the needs of its customers. >

KUKA is expanding: more production capacity in China

The Asian-Pacific region is a high growth market. This is why KUKA is further expanding its locations in this region and presenting products that are tailor-made for the Asian market. In its Shanghai-based Asia hub, KUKA has centrally concentrated various functions for the local companies since 2016. General services and consultancy services have been transferred from the individual regional companies and pooled at the hub, so that all expertise is concentrated in one place and the employees can collaborate efficiently across all of Asia.

Last year, the KUKA Industries division began with the expansion of its Kunshan location.

Since 2013, KUKA Industries has been designing and implementing turnkey robotic systems specifically for the Chinese market with a workforce of around 300 thus far. In November 2016, a ceremonial groundbreaking signaled the start of construction for the new building in the industrial city west of Shanghai.

Various projects pertaining to automation in the fields of battery production, casting technology and intralogistics are prefabricated and tested over an area of almost 18,000 square meters. The hall will be ready in January 2018 and can accommodate up to 200 additional workstations. The Swisslog division, which has been developing and assembling logistics systems in Kunshan since 2008, will also be working on automation projects in the new hall.

In addition, the Robotics location in Songjiang is expanding. The construction of a second production facility started in January 2017. <

The groundbreaking ceremony in Kunshan, China for the new building of KUKA Industries, with CEO Alwin Berninger.





Top left: The electronics industry is an important growth market for robot-based automation and requires tailor-made solutions.

Top right and bottom: The KR 3 AGILUS at the China International Robot Show (CIROS) 2016 in Shanghai – ideal for the electronics industry.

Premieres in Shanghai: product launches for new markets and industries

The new product series KR CYBERTECH was launched at the China International Industry Fair (CIIF) in Shanghai in November 2016. This includes compact robots that can be used for loading and unloading machines as well as for welding.

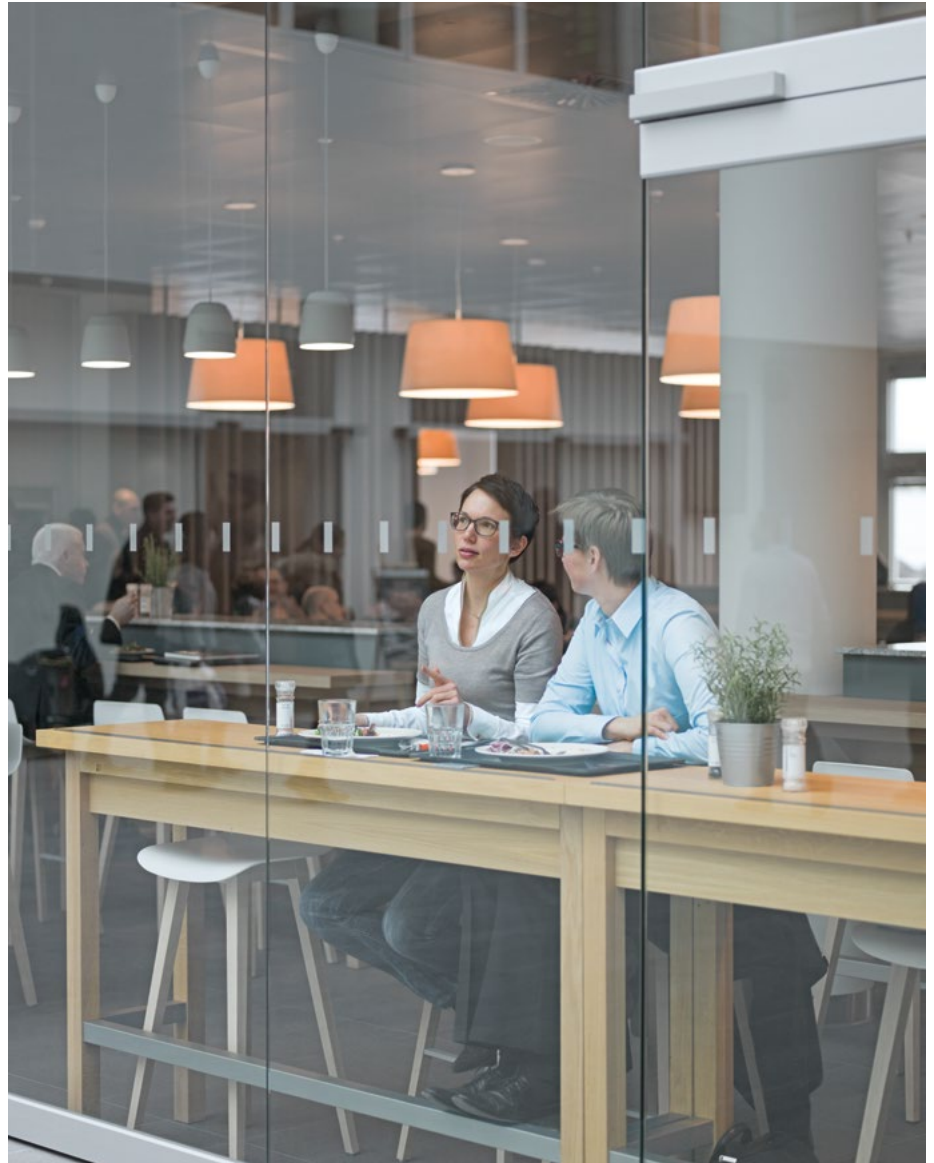
Previously, in July 2016, KUKA had presented a tailor-made robot for the 3C market (computers, communications and consumer electronics) to the Asian audience at the China International Robot Show (CIROS) in Shanghai. The newest member of the KR AGILUS family of small robots is extremely compact and thus an ideal solution for small cell concepts. In the Asian electronics industry, where production changeovers are frequent, it is crucial that the robots can be used flexibly. This was a major factor prompting KUKA to develop the KR 3 AGILUS. As the fastest six-axis robot in its class, it masters tasks that are required not only in the electronics industry, for example packaging applications, handling and component testing. <





TRADITION MEETS INNOVATION

Development and Technology Center in
Augsburg inaugurated



„We wanted to create an environment where our employees enjoy working and which is conducive to collaboration and creativity.“



Dr. Till Reuter

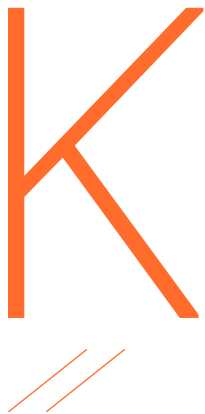
„It is very transparent. If you go up these stairs, you can see into the offices of your colleagues, and they can see you.“

Dr. Till Reuter

“Economic progress is currently being impacted by three major trends: globalization, automation, digitization – and KUKA is right in the middle of it,” was how EU Commissioner Günther Oettinger put it succinctly when he was invited to the inauguration ceremony at KUKA last summer.

Innovative strength is what makes technology corporations successful and future-proof. The investment in the DTC is also an investment in R & D. It is the heart of KUKA, which is firmly rooted in Augsburg. With floor space of 39,000 square meters, the facility accommodates around 850 workplaces, more than half of them in R & D. The research and development activities are pooled at the DTC in order to create further innovations and products of tomorrow. Besides Günther Oettinger, other guests from business and politics were also invited to the inauguration of the new building. The ceremony was wholly dedicated to KUKA’s technologies, products and solutions for Industrie 4.0 and, by association, the digitization of production. Bavaria’s minister of economic affairs Ilse Aigner acknowledged the building as “a clear commitment to the Augsburg site and Bavaria as the company base.”

After the scheduled construction period of two years, the first employees were able to move into the building as planned at the end of 2015. The open-concept building provides a suitable setting for the creativity, innovative thinking and interdisciplinary cooperation needed to shape Industrie 4.0. Furthermore, the DTC houses an impressive showroom and KUKA College, where 7,000 customer employees are to undergo training each year. >

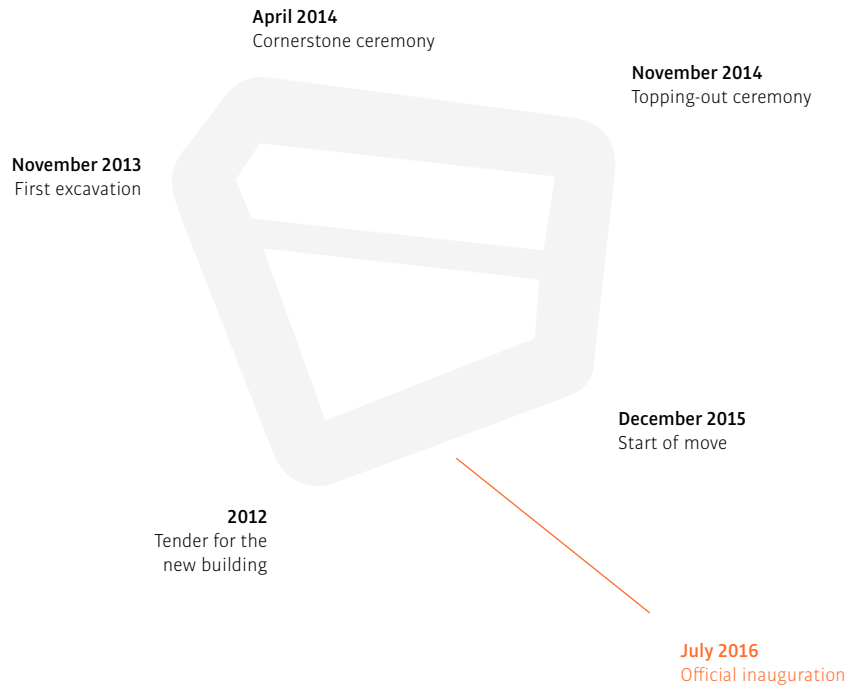


KUKA stands for Industrie 4.0 made in Germany. Deeply rooted at its home base in Augsburg where the success story of KUKA began almost 120 years ago. The new construction of the prestigious Development and Technology Center (DTC) is a landmark for KUKA’s progression. It represents the rapid growth of the company and also marks the starting point of the digital transformation. KUKA is quickly evolving into a global group, while also investing in its headquarters in Augsburg, where about 3,500 employees are working on the digital transformation of production. “The construction of the DTC is a clear investment in the future. Our traditional location in Augsburg is the basis for our global success,” emphasizes Dr. Till Reuter, CEO of KUKA AG. The modern building reflects the fusion of tradition and innovation. “This is where our employees combine mechanical engineering with the world of IT,” says Reuter.

A popular meeting place for lunch – the modern canteen is a great venue to share a meal with colleagues.



“The atrium provides an area where people can converse and network. It is like a marketplace. You meet and start a conversation. You exchange ideas.” Dr. Till Reuter



„This is where our employees combine mechanical engineering with the world of IT.“ Dr. Till Reuter





„A clear commitment to the Augsburg site and Bavaria as the company base.“

Ilse Aigner

Top left: Ilse Aigner, Bavaria's minister of economic affairs and media, energy and technology.



Top: Ursula Heller, journalist and television host in conversation with EU Commissioner Günther Oettinger and Dr. Till Reuter

Bottom left: Two mobile KMR iiwa robots assisted at the ribbon cutting ceremony.

„Economic progress is currently being impacted by three major trends: globalization, automation, digitization – and KUKA is right in the middle of it.“

Günther Oettinger

LOOKING TO THE FUTURE

How KUKA manages its own innovations

The word innovation comes from Latin and literally means renewal or change. New ideas and inventions are essential for technology companies, which is the reason why they are not left to chance. The team led by Chief Innovation Officer (CINO) Dr. Bernd Liepert is fervently addressing the question of what KUKA customers may need in 2032. This involves studying trends and exchanging information with research institutes. Innovation manager Elisabeth Schärtl explains how it works.



What does your job as Corporate Innovation Manager at KUKA entail?

Schärtl: In layman's terms: I'm looking into the future for KUKA. What will the world look like in 10 – 15 years? What will change? Particularly important are megatrends and how these impact people's behavior. Just look at digital natives, for example: for them, using smartphones and tablets is already a matter of course. Using robots will also be second nature to them, and they will define new applications for the robots. Or megatrends such as demographic change and globalization. It is our job to identify, on this basis, our customers' future needs, the problems they will face and the solutions that they will require. These are some of the questions we deal with. >



» Technology scouting is an important issue. You have to keep your eyes peeled at all times.«

Elisabeth Schärtl

To find appropriate solutions, you need accordingly advanced technologies. How do you track down key technologies that may be relevant?

Schärtl: Technology scouting is an important issue. You have to keep your eyes peeled at all times and think outside the box. After all, there may be interesting technologies around which are used in areas other than robotics, and which may be adaptable to robotics. This is why we cultivate long-term and very close contacts with the research community and maintain a lively exchange.

What sort of background and qualifications does a job like this require?

Schärtl: In terms of our team, I would say the secret lies in the mix. We are all from different sectors: natural sciences, humanities and social sciences. This allows us to approach trends and innovations from vastly different viewpoints. It enables us to look at the whole picture. If you take human-robot collaboration, for example, a business psychologist and an engineer focus on completely different issues. The psychologist asks how this sensitive robot may affect humans, how it will react to humans and what functions humans expect of a robot that is able to move within



Innovation Manager Elisabeth Schärtl networks intensively as part of her job.

1

Competitive edge through networking

Swisslog is supporting British customer TJ Morris with Industrie 4.0 solutions for more efficient work processes. At the core is the cloud-based KUKA Connect platform.



TJ Morris Ltd. with its “Home Bargains” stores is one of the fastest growing discount retailers in the UK. The company was established over 40 years ago by Tom Morris. Since the first store was opened in Liverpool, the business has grown organically and has become one of the biggest privately owned companies in the UK with 400 stores and over 17,000 employees. This makes it the largest employer on Merseyside and the nation’s largest independent food retailer. TJ Morris continues to grow. The stated goal: 800 stores and more than 30,000 employees in total.

Optimized processes can help achieve this objective. TJ Morris has been a Swisslog customer for many years, making it an ideal partner for talking about Industrie 4.0 solutions. A joint workshop in 2016 was used for a lively

exchange of knowledge, which quickly resulted in potential applications being identified for the cloud-based solution KUKA Connect. KUKA Connect collects and processes the entire information from all networked devices on a central basis. This knowledge allows users to register error messages in real time, to monitor maintenance activities and condition data, and to produce comprehensive event logs.

TJ Morris would benefit from a major competitive advantage by integrating the Swisslog data into an enhanced planning system deployed across all stores and sites. An XML database is currently under joint development in order to implement a computerized maintenance management system (CMMS) at an additional site. This is the ideal basis for developing further Industrie 4.0 solutions, such as a

pilot system for predictive maintenance scheduling with associated event notification. Furthermore, KUKA Connect has been defined as a professional front end application for TJ Morris’s ongoing developments. This means that in the future TJ Morris can serve as a proof of concept platform for integrating Swisslog products into the tool.



their environment – coming closer to them in daily work, so to speak. For example in assembly activities, where the robot may assist humans with joining tasks. The engineer, on the other hand, considers the technical possibilities. Interdisciplinary collaboration is very important.

Speaking of interdisciplinary approaches: how do you convince colleagues of the validity of an innovation? Not everyone thinks that far ahead.

Schärtl: That is true. Regular communication with colleagues from other areas, such as sales, project management and development is important in order to keep your feet on the ground. On the other hand, we also need to enthuse our colleagues in the company about technologies and innovations, so that these will be widely accepted within the company. Companies operate in the now and in the near and foreseeable future. It is important to strike a balance between these two worlds.

How are the Development, Corporate Research and Innovation Management departments demarcated?

Schärtl: The Innovation Management department looks the farthest ahead. We examine how the world might look like in 10 – 15 years and extrapolate customer needs and possible solutions which KUKA may be able to offer. Corporate Research focuses on the somewhat nearer future. This department researches and develops technologies, collaborating with research partners in the context of funded projects at EU level, for example. From idea to demonstrator, so to speak. Once the demonstrator has been successfully evaluated, the next stage – series development – begins. <

2 //

Teamwork in confined spaces

At BMW, humans and robots work hand in hand. In a team effort, they lift the differential cases for the front-axle transmissions and join them together – without any protective fences or external safety technology.



One of the challenges was the small space, because the system had to fit into the production line. To achieve this, a streamlined gallows-shaped steel structure was built at the manual workstation, on which the sensitive LBR iiwa lightweight robot is suspended. The robot's gripper was equipped with an edge-free HRC case with a rounded design, so that the operator is protected from injury at all times.

At this new workstation, the team consisting of a human operator and a robot needs only half a minute to fabricate the differential case. The operator performs the tasks that are not as physically strenuous. For example, he places the small and lightweight parts, such as spacers and ball bearings, into the transmission case and the cover. The operator then activates the robot, which carefully fits the heavy differential case in place. The robot's tactile capabilities facilitate the process of meshing the delicate tooth flanks into the gears. The operator then fastens the cover to the transmission. The advantage: the job is less strenuous for the human coworker. Today, production facilities are increasingly tasked with handling many variants. Flexible HRC units can provide a clear competitive advantage by allowing production to adapt to the capacity requirements. <

For about a year, the specialists from the Application Engineering Team at KUKA Systems tinkered away together with their colleagues at BMW in order to find this HRC solution. HRC stands for human-robot collaboration. Where BMW employees previously had to lift and fit cumbersome differential cases weighing up to 5,5 kilograms with millimeter precision when assembling front-axle transmissions, the robot now performs this ergonomically demanding task.

CAN ROBOTS DREAM?

How robots use idle periods to learn

Corporate Research is currently working on the EU-funded project RobDREAM, among other things. “Much like humans process and consolidate their daily experiences during sleep, the idea is to make robots do the same,” explains Dr. Rainer Bischoff, Head of Corporate Research.

This means that robots use idle periods to process the empirical knowledge gained during operation. In this way, times of inactivity are used to enhance the capabilities of the robots in order to achieve a faster performance the next day.

How does it work? “During idle periods, sophisticated optimization calculations run in simulations,” says Bischoff, offering up the following example of a typical application in which a robot is tasked with assisting a component picking process: the components are to be retrieved from a warehouse and made available in a box for the subsequent assembly operation. To learn this task, it suffices to show the robot the individual components and define the quantities for a particular picking process. The robot detects the components to be picked in the warehouse using a 3D camera, grasps them and places them in the desired box one after the other. During the working day, the robot figures out where the components are typically located in the warehouse, where obstacles are and where the empty boxes are. Ultimately, the robot reaches an optimum speed of execution as a result of simulation and experimentation with different path planning algorithms and sets of parameters. <



The EU-funded project RobDREAM: the robot optimizes its workflows through extensive simulations during idle periods.

GENERATION R – ROBOTIC NATIVES

How innovations affect social changes

Dominik Bösl is also an innovation manager at KUKA. One of the questions that he deals with: how do innovations impact the future and society?



Mr. Bösl, we frequently read about how robots will be hailed a technical achievement similar to smartphones not long ago.

Bösl: Robotics will change the world! Robots, automation technology and artificial intelligence will develop at least as much potential to shape the next half-century as the Internet, computers and smartphones had in the past half-century. Personally, I'm convinced that these technologies will become a mainstay and enrich our everyday lives.

We are certain to witness this trend – making us the very first robotic immigrants – albeit with a very analog migratory background, but this will quickly change. For our grandchildren, robotics will be second nature – they will be the first generation R of robotic natives!

As someone who deals with innovations on a daily basis: are these all positive changes or are you also considering the risks that disruptive technologies can bring with them?

Bösl: Revolutionary technological inventions mean change. Initially, people are always skeptical. When the first rail lines were built, the prevailing skepticism was that the human body would not be able to survive the incredible acceleration and high top speed of up to 30 kilometers per hour. We may laugh at this today, but robotics and artificial intelligence are subjected to the same kinds of controversial discussions, which, unfortunately, are not always positive.

What is the source of this, in your opinion?

Bösl: There are two primary reasons: for one, robotics and artificial intelligence have arrived in the public perception through the so-called “Hollywood effect”. In the last year alone, more than ten Hollywood blockbusters have dealt with this topic – and audiences love science fiction. On the flip side, we also have neo-Solomonic experts opining on the issue. Unfortunately, this topic is viewed in terms that are often too broad, and unrealistic horror scenarios such as the Terminator or rampant artificial intelligence are conjured up.

Let's change topics for a moment. Much is written about the potential loss of jobs due to robots becoming more and more intelligent.

Bösl: History and statistics show that technology – and especially robotics and automation – has created more jobs since the first industrial revolution than the number of jobs lost during the same period. Just look at the automotive industry, for example.

However, the job profiles of certain occupations will be changed by technology. So we must ask ourselves how we can educate the industrial workforce in the future and what the appropriate vocational training should look like. This is why companies like KUKA are collaborating with research, industry and workers' organizations. <

»History and statistics show that technology has created more jobs since the first industrial revolution.«

Dominik Bösl



Dominik Bösl,
Innovation Manager at KUKA

Dr. Bernd Liepert, Chief Innovation Officer (second from left) and Dr. Rainer Bischoff, Head of Corporate Research (left) presented the lucky winners their prizes at Hanover Fair.



KUKA INNOVATION AWARD

For many years now, KUKA has been working closely with university and R & D partners from all over the world. Under the patronage of Dr. Bernd Liepert, Chief Innovation Officer of KUKA Group, KUKA launched the Innovation Award to promote innovation in the field of robot-based automation and to support technology transfer from science to industry.

The research competition is aimed at developers, graduates and research teams from companies or universities around the world. The participants develop ideas for tackling challenges specified by KUKA. The finalists, selected

by a jury of experts, implement their projects using KUKA hardware and present the results to wide-ranging specialist audiences at major trade fairs. The winners receive a monetary prize of 20,000 euro. The award was first presented at Automatica 2014.

In 2016, a research team from Johns Hopkins University in Baltimore impressed the specialist panel with a system that enables users to react to new situations or external influences and to redefine complex tasks for the robot. The year before that, a young team from Italy won the award with an upper-limb exoskeleton that communicated with the sensitive LBR iiwa lightweight robot. <



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Technology for perfection

Using their process know-how, the experts from KUKA Industries are optimizing the manufacture of XXL cranes, creating the basis for competitive steel construction products through the use of sophisticated processes.

Truck-mounted cranes are impressive. With a height of up to 100 meters, these slender giants are head-turners on every construction site. That reach may suffice for many high-rise buildings and most bridges, but not the construction of wind turbines. Thanks to a telescopic arm, an additional extension of 92 meters is made possible. The booms for telescopic cranes are welded together lengthwise from two half-shells. And the welds have to withstand very heavy loads – these cranes lift up to 1,200 tonnes. Even with the ever increasing demands on load capacity and boom length, the weight of the crane itself must also be optimized. High-strength steels are used for the purpose of lightweight construction here.

When two folded plates are welded over such lengths, thermal distortion can result. This is a quality risk that can have serious consequences if neglected. But for welding specialist KUKA Industries, this is not a problem: using a laser hybrid welding process, the weld distortion has been reduced to virtually zero, so that the boom components no longer have to be manually reworked in these areas. Further advantages: welding at very high speeds is possible and the molten weld pool is relatively small. The laser beam is focused with great precision and generates a very deep and narrow seam with low heat input into the component. The greater welding depth obviates the need for welding from inside with the result that only two seams are required.

With a maximum component length of 22 meters and two continuous weld seams, determining the actual position of the component within the system is a major challenge. Such bulky components can never be manufactured and positioned without minor dimensional tolerances. KUKA Industries offers its customers exact seam tracking with an integrated laser camera which is able to meet the requirements and cope with the extreme conditions at the welding head. In conjunction with specially developed software, the camera monitors correct seam tracking and ensures process reliability even at the highest welding speeds.

The system is based on a gantry robot, which is able to travel along the entire path of the long components without the position of the component having to be changed. It is equipped with hybrid welding optics specially developed by KUKA Industries. A single clamping set-up in the cell is sufficient for execution of the entire welding process. The elimination of distortion leads to a further reduction of the clamping equipment requirements.

This unique system shows how innovative, sophisticated techniques enable the competitive manufacture of steel construction products in Germany that can also help to save resources. It incorporates a process that has been enhanced to perfection. <

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