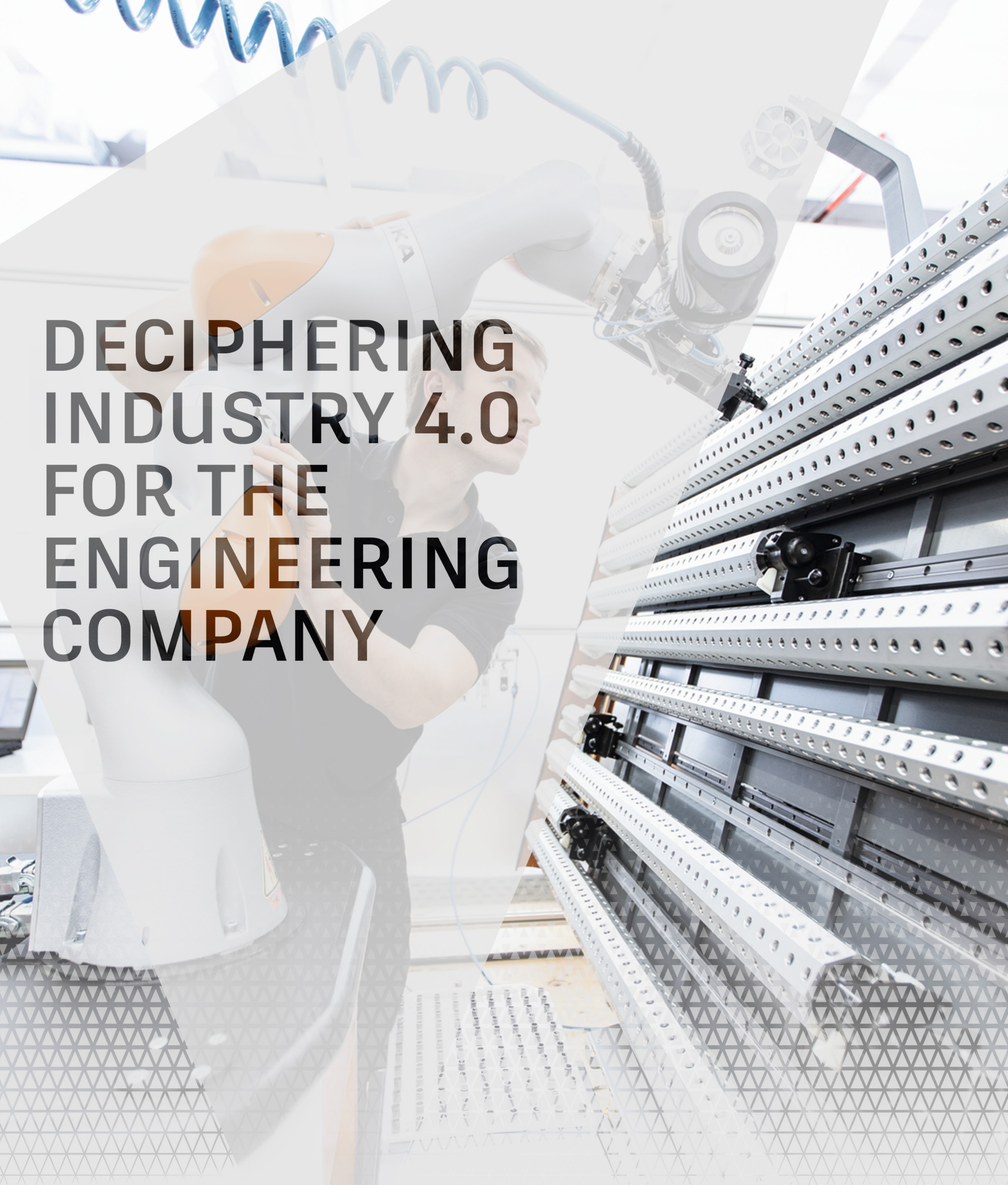


DECIPHERING INDUSTRY 4.0 FOR THE ENGINEERING COMPANY

AUTODESK

KUKA

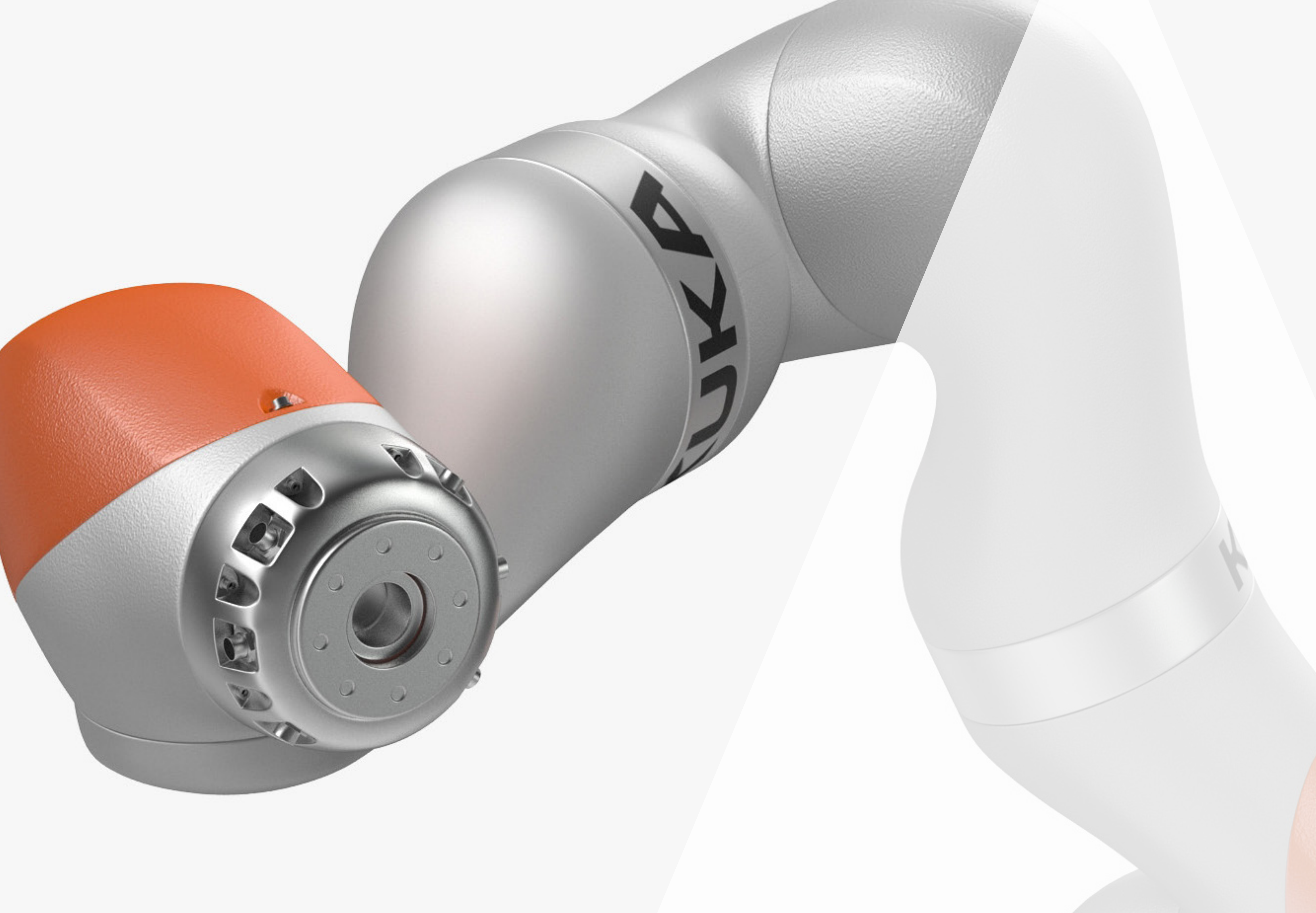
OBJECTIVE

The terminology of the future manufacturing state – Industry 4.0, 4IR, Fourth industrial revolution, Industrial Internet of Things, cyber physical systems, machine learning – has become a new industrial language which has lost many of its target audience. While most engineers and manufacturing executives know of these terms, the jargon can be confusing and off-putting to many companies, especially SMEs, who simply want to know: what does it do and what is the value proposition?

Autodesk and KUKA Robotics UK have combined to explain how some of the new digital technologies that will transform manufacturing – including cloud computing, digital twins, generative CAD design and collaborative robots – really work and what they can do for smaller companies. Our chosen approach is not to baffle the end-user with buzzwords but explain the technology and the opportunities and how companies are using it.

Some of the central terms in the Industry 4.0 lexicon are really important to manufacturing industry as it evolves.

- ► Agility, for example, refers to the greater responsiveness of factories to consumer demands. While mass personalisation is still in its early stages, and is better suited so far to consumer durables like cars than commodity goods, digital technology is and will be needed in manufacturing lines for products like cosmetics and soft drinks, where the same dispensers can fill bottles in series with different fluids to ship mixed batches, reducing packing time. KUKA Smart Production says that tomorrow “product lifecycles will be shorter than the lifetime of the production system”.
- ► Digital twins are the simulated offline versions of real parts and assemblies that reveal how they physically behave before they are manufactured. This technology is getting very sophisticated so engineers can test a wider range of physical and mechanical performance metrics offline before the cost of making the first one-offs.
- ► The cloud factory – really means a factory where the operational data needed to run machines and processes are stored in the cloud, rather than a fixed data centre. Cloud access becomes very relevant in a machine learning environment, when machines like robots are expected to “learn” new actions by interpreting data from their environment, such as face recognition to work alongside a human operative. The cloud enables the passage of operating data to the ‘deep learning’ phase of machine learning, and to feed this back to a robot to optimise its next operation.

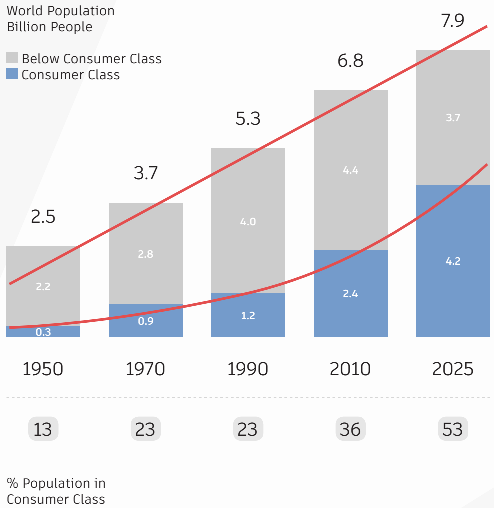


BACKGROUND

These connected factory technologies are not being developed to force or scare companies into buying more software or equipment. They are here to solve real world problems.

KUKA's Industrie 4.0 and Smart Factory report summarises this nicely. By 2025, in just eight years, there will be about 8 billion people in the world, half of them in the "Consumer Class", people who routinely purchase items like consumer durables (cars, white goods etc). Populations are aging, and the population in Germany and some developed countries is slowing or shrinking. If manufacturing productivity in high cost countries does not improve there may be more offshoring to low cost countries – even though there is evidence of reshoring production from Asia. There is a growing demand for personalization of mass produced products, we want to customize what we buy – only automation can do this economically. Robots and other machines will be used as "assistant systems" for workers, aka the Human Robot Cooperativte.

More drivers for the "fourth industrial revolution" are well documented. In short, digital technology can keep manufacturing viable in developed countries and deliver the customisation that people want, economically, with more variety than has been possible, with an often ageing and "manufacturing-neutral" workforce. The last point refers to the manufacturing recruitment challenge; if countries like the UK cannot attract more people to work in factories, technology will have to do the work.



CHANGING THE RULES OF THE GAME

Production agility and market responsiveness.

Quite simply, companies will need to be more agile to respond to changing product iterations and varying demand volumes more quickly in the future. Part of the key is to connect devices to give factories more information.

The Internet of Things, as we know, is about connecting industrial devices together. How does this translate into better business?

One area is connecting customer demands to production. Companies now want to re-iterate their products quickly; they cannot afford to be tied into rigid production processes to make colossal quantities of products of each iteration, if consumer tastes or design intent changes mid-run.

“The challenge facing industry is how can we make manufacturing processes more nimble so they can support the more nimble approach to product evolution?” says Steve Hobbs, Vice President of CAM and Hybrid Manufacturing at Autodesk.

Companies like Autodesk and KUKA are addressing this in two main ways:

1) Apply one-off prototyping / tool-making technology into volume production
The kind of CNC devices commonly used in tool rooms and job shops were all about making one-offs. This needs quite deep knowledge to, for example, make an intricate mould tool that will mould a million parts. The tool-making knowhow needs to be applied more quickly to mass production.

2) Robot reprogramming
Typically an industrial robot is not treated as a reprogrammable device.

It would be programmed in situ in a sequence of specified moves, also known as the teach pendant. The robot performs one operation like spot welding or lifting until it gets scrapped because a new line is started elsewhere. CNC machine tools are very much reprogrammable devices.

“We want to apply the technology we use with CNC cutting for example to make it much easier for robots and other automation devices to be reprogrammed on the fly.”

Steve Hobbs
Vice President of CAM and Hybrid Manufacturing | Autodesk

The better use of, the optimisation of, robots to do things beyond their original sequential task remit is a key part of the Industry 4.0 evolution. KUKA is using new digital tools to programme ultra-efficient smart factories covering key technologies such as mobile robotics, machine learning, reconfigurable production cells and collaborative robots. The rapid growth in the versatility of robots in recent years is remarkable, driven by the need for agile manufacturing.

“Industry 4.0 should not be seen as a solution or product, per se,” says Jeff Nowill, CEO of KUKA Robotics UK and KUKA Ireland.

“It is a way of making any manufacturing environment more market and demand appropriate by employing technology to seamlessly and automatically improve cycle time, batch-magnitude, process characteristics, quality or manifestly change output according to – or even anticipating –demand. As such, it is a vehicle to be a better manufacturer, but it’s primarily about having the right value-proposition to start off with.”

Key business benefit: Production can be completed more quickly than it can in “analogue” or unconnected factories, delivering greater variation to customers in high volume, while simultaneously increasing speed and reducing waste.

Agility: Companies cannot afford to be tied into your production processes to make colossal quantities of those products on each iteration.

DIGITAL TWINS

Build and test offline.

An essential point of smart factory technology is the ability to design and test products – and their manufacturability – offline before anything is made for real.

“We cannot experiment with the physical equipment, because if we take down the production line we will be losing output and we kill the economy of scale. Stopping an automotive plant can cost £10,000 a minute,” says Bart Simpson, Senior Director, Operations at Autodesk.

Much of the 3D design, physical property analysis (FEA), and factory performance simulation can be done offline with a digital twin, a digital replica of the part or machine on screen, with all its working parts. These tools allow engineers to get, often complex, products right first time without building a prototype.

“Making one-offs in tool rooms, you cannot do trial and error. If you made a part and “try it out” before you make the one-off, you have put 100% overhead on your process. So you need tools to make sure you get it right first time.”

Steve Hobbs
Vice President of CAM and Hybrid Manufacturing | Autodesk

But engineering simulation (CAD and CAE) have been around for years. The next “Industry 4.0” phase requires two things:

1) Richer simulation tools
Autodesk now has clever simulation tools for metal cutting, and additive manufacturing processes, as well as more traditional finite element analysis tools.

2) Higher accuracy
Better technology means greater assurance that these simulations are aligned to what actually happens in production

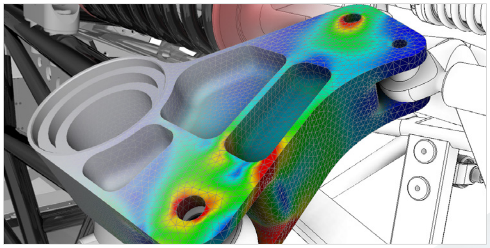


Image courtesy of Briggs Automotive Company Ltd.

“Smart factories are about connecting devices, ” says Bart Simpson. “Connecting devices has been around for some time but it has been difficult to glue those connections together and aggregate data in a meaningful way. Now this is possible.”

Such powerful simulation also benefits factory planning and robotic operations. A big area for the smart factory is standardised

Business benefit: Next generation software can interrogate parts, products, machines and factories to reveal design flaws and cost-saving solutions more accurately and quickly than was previously possible.

THE FACTORY AND DATA

What is my data and where does it go?

The data in a machine shop environment includes spindle speeds, number of revolutions, temperature, coolant temperature and levels, tool wear, tool changeover intervals and machine running time. Also parts produced in a shift and quality defects.

CNC controllers are powerful computers in their own right. Under business-as-usual or "Industry 3.0", many machine operators are not using them to the potential, rather just as a programmable interface. Inside the CNC are gigabytes of useful performance data.

Let's compare two scenarios, business as usual and Industry 4.0.

Industry 3.0 machining

In a traditional CAD/CAM environment, one would programme a part, generate the G code to drive the machine, and typically get an inaccurate estimate of how long it would take to cut the part.
"The reason for this is that we don't have real performance data for that machine," says Steve Hobbs. "It has finite spindle acceleration and processing time for the CNC controller, things which mean it does not move instantaneously. In reality parts will take longer to cut than we expect."

Engineers build in fudge factors that add e.g. 20% to the expected time, but it is hit or miss.

"Industry 4.0" machining

This is Industry 3.0 with feedback.

Machine performance data can predict how long a job will take. The job is run on the machine, live feedback from the machine measures how long it took and the operator can start to correlate the results and learn from them. Engineers can use simple manual correlations or a smarter machine learning approach to collect the data.

Virtuous circle: When companies can feedback the true experience data from their factories, they can improve the quality of their digital model used to simulate that facility and therefore the accuracy of the simulation and the reliability of the results can be improved. The aim is a "virtuous digital circle" where the simulated production processes are a much more faithful representation of what will really happen on the shop floor, eliminating guess work.

Business benefit: "The advantage is to harness manufacturing data and make it visible, in real-time across the supply chain. The benefit is to connect people, data, and machines to improve production efficiency, better decision making and enable an agile response to demand."

WHAT IS THE CLOUD FACTORY

Cloud computing has also become a buzzword and there is a spectrum of true understanding of its role in smart factories.

By using a cloud platform, or simply, moving and storing industrial data offline using the internet or local network as a interface, the wireless connections between the product and machines at the “field level” can speak instantly to the enterprise level systems like ERP and MES SCADA systems at the top level of the enterprise.

In yesterday’s regime, product and field data – such as product defects, machine optimisation data like spindle speed and temperature – remained on the shop level and had to be manually fed into an enterprise IT system.

Architectures like KUKA’s Edge Cloud Gateway does all this automatically. A board meeting can pull up real-time shop floor KPIs as the line is running, from the ERP system. The cloud makes this possible.

“The driver for Industry 4 is the desire to use technology to the point where it becomes easier to connect the operation via cloud connections, and we can aggregate data much more easily where, with for example Autodesk Fusion 360 Production and other cloud tools, you can pull the data in from different factory sources to a database and you can start to link that data together, recognise patterns and see trends,” says Steve Hobbs, Autodesk.

Business benefit: The I4.0 difference is that finally the process interrogation that manufacturing engineers have discussed for years are feasible because they have access to connectivity that they never had before. The cloud enables this.

NEW BUSINESS MODELS

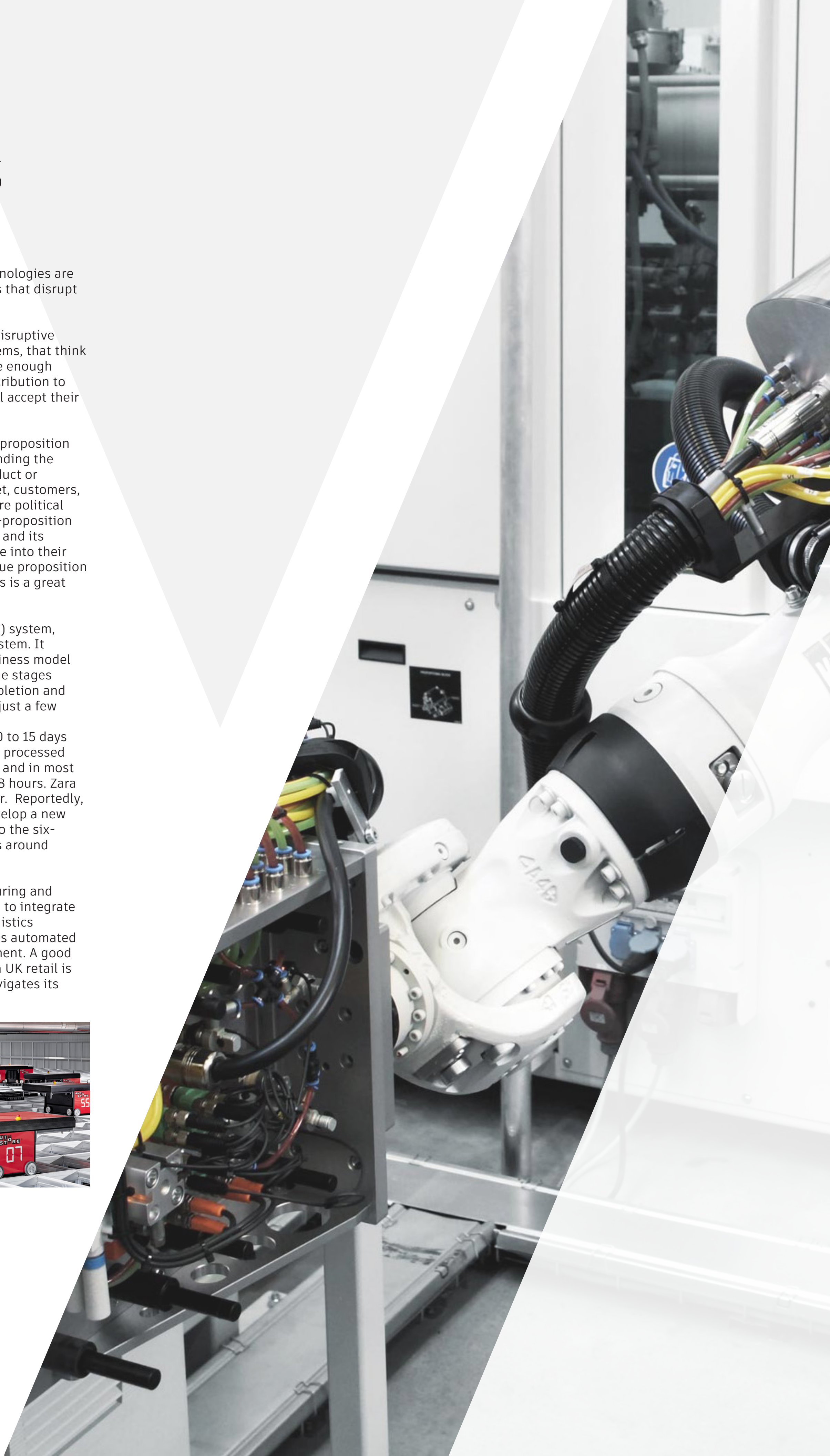
“Industry 4.0” factory and logistics technologies are enablers for mould-breaking businesses that disrupt established norms.

Jeff Nowill of KUKA Robotics points to disruptive businesses that rebuild traditional systems, that think like their customers and which are brave enough to remodel their manufacturing and distribution to deliver this, rather than hope people will accept their rigid system.

“Again, companies need the right value-proposition to begin with. That’s a case of understanding the complex relationship between your product or service within the context of your market, customers, competitors and the prevailing and future political climate. That gets a class-leading value-proposition to the table and thereafter, Industry 4.0 and its associated digital technologies can come into their own to ensure the application of the value proposition is world class. Zara the clothing business is a great example of this.”

In 1990 Zara adopted a just-in-time (JIT) system, modified from the Toyota Production System. It enabled the company to establish a business model that allows self-containment through the stages of materials, manufacture, product completion and distribution to stores worldwide within just a few days.
After products are designed they take 10 to 15 days to reach the stores. All of the clothing is processed through the distribution centre in Spain and in most cases, the clothing is delivered within 48 hours. Zara produces over 450 million items per year. Reportedly, Zara needs just one or two weeks to develop a new product and get it to stores, compared to the six-month industry average, and it launches around 12,000 new designs each year.

To integrate such demanding manufacturing and delivery schedules, companies will need to integrate smart factory technology with smart logistics solutions and equipment such Swisslog’s automated picking robots and warehouse management. A good example of fully automated fulfilment in UK retail is Ocado, which picks all its orders and navigates its huge warehouse automatically.



KUKA CASE STUDY - ZND UK

Myth busting: Robots create jobs

Despite the common belief that automation removes jobs in the automotive industry, the opposite is happening in Germany and some nations. From 2010-2015, the number of employees in the German automotive industry expanded by 14% to reach 710,000 workers by late 2016 (Source: Euromonitor).

ZND UK in Rotherham is Europe's largest manufacturer of temporary fencing and pedestrian barriers. Since 2012 it has had a fully automated robot-operated line to feed wire coil to the fence assembly process, to braze on supports, further value-add operations and handle the material between cells. Engineering manager Paul Fenwick says without the KUKA robotic line, the process would need 16-men per shift. With robots, throughput has risen from 80 per line per shift, to 500 per line per shift – a rise of 600%. Robotic brazing has created a better product, so demand has increased, meaning more recruitment to man the lines. For ZND, the term "Industry 4.0" may be irrelevant but by automating the factory fully it has raised output to meet demand, increased quality and created jobs.

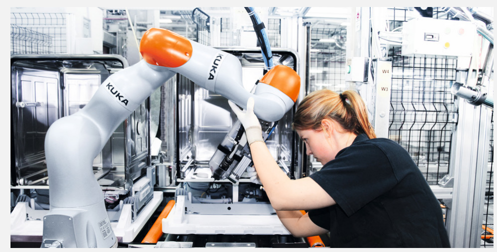
We hope you have found this white paper useful.

Please get in touch with Autodesk and KUKA Robotics if you wish to discuss any part of this report further.

Coming Up Next.....

The second Autodesk and KUKA Robotics paper on Deciphering Industry 4.0 will investigate:

HUMAN AND ROBOT COLLABORATION



As manufacturing companies seek to automate the assembly of products more and more, human and robot collaboration is a growing field. Companies that are used to assembling complex structures fully manually know that one way to increase throughput is to develop reliable and safe systems where humans and robots can work side-by-side.

Much research is being done in this area, in the UK especially at Cranfield and Loughborough universities, and more companies are installing collaborative robots, or "cobots", to assist workers with desk-based and light, repetitive assemblies and inspection tasks. Our white paper discusses the latest advances in this field and demonstrates the business case.

Expect the next paper out in SEPTEMBER 2017.

Our third paper will continue to explore Smart Logistics and Mass Customisation and our fourth paper will discuss Generative Design & Artificial Intelligence.

Reference links

- **Industrie 4.0 and collaborative robots in German car industry**
  http://blog.euromonitor.com/2016/10/industry-4-0-german-car-industry-introduces-collaborative-robots.html
- **How robots will change the workforce**
  http://phys.org/news/2016-12-robots-workforce.html
- **The Ocado warehouse run by robots**
  http://www.bbc.co.uk/news/av/business-38897417/the-ocado-warehouse-run-by-robots
- **The Zara business model**
  http://uk.businessinsider.com/why-zara-is-crushing-the-retail-industry-2016-5
- **Seeing Digital Twin Double**
  http://www.digitaleng.news/de/seeing-digital-twin-double

DECIPHERING INDUSTRY 4.0 FOR THE ENGINEERING COMPANY

AUTODESK.

KUKA

www.autodesk.com

www.kuka.com