4.0 sight

digital industry
around the world

contents

Meet the authors

Mark Proctor & Jonathan Wilkins

We're back again! Following the success of our last book: BoOM! The Book of Obsolescence Management, we've published our second and you're holding it in your hand. Readers told us that BoOM! helped them develop a formal plan for managing their technology lifecycle.

Since then, we've also been on a journey as a business, expanding internationally. On our travels, we've spoken to lots of people and one of the recurring issues we saw was that different countries are on different points in their journey to digitalisation.

However, far from being an issue that divides us, we realised that people have given different names to technologies and programmes that we have in common. These ideas make up the umbrella term Industry 4.0, the unifying phrase that describes the Fourth Industrial Revolution.

So, we decided to write this book to serve as a roadmap for the pioneering initiatives and cutting-edge technologies changing the world. Here, you'll gain insights from experts that hail from a mix of industries and find our predictions on how the technological landscape will change in the coming years.

We started with a BoOM! but we think the change we are experiencing is more of a big bang.

1

From Industry 4.0 to Society 5.0

A global view of
the Fourth Industrial Revolution

For as long as people have had the means to change their surroundings, they have found new ways of improving them. This inherent aspiration, to improve the human condition, has led to historic achievements - from the first use of tools some 2.5 million years ago to the building of the Great Pyramids of Giza, and the first flight by the Wright brothers to the moon landing.

However, these achievements, while ground breaking, have only been made possible because of the conditions of the time. They have been the culmination of a collective learning and advancement on a grand scale. Each successive breakthrough has been made possible because of the combined work of everything that went before it.

> **“Each successive breakthrough has been made possible because of the combined work of everything that went before it.”**

In the modern history of the world, these breakthroughs have manifested themselves as concentrated periods of change. The combination of advancements in transport, infrastructure, agriculture, policy, engineering and technology have led to what we now call industrial revolutions. These periods of intense upheaval have been responsible for the changes we've experienced over the last 250 years and are broadly categorised into four groups.

According to Klaus Schwab, founder and executive chairman of The World Economic Forum, Geneva, "The First Industrial Revolution used water and steam power to mechanize production. The Second used electric power to create mass production. The Third used electronics and information technology to automate production.

Now a Fourth Industrial Revolution is building on the Third, the digital revolution that has been occurring since the middle of the last century. It is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres."

> **“Now a Fourth Industrial Revolution is building on the Third, blurring the lines between the physical, digital, and biological spheres”**

Although the revolutions themselves are nothing new, what is changing is the speed at which they are occurring. The pace of change in ancient societies, such as that experienced in Greece, Rome and China, was on a scale of hundreds or thousands of years, periods literally referred to as ages, eras or dynasties. In contrast, the industrial revolutions of the 18th and 19th centuries shortened the time span between successive revolutions to less than a hundred years.

By various estimations, the first Industrial Revolution (1770–1850) lasted around 80 years; the Second (1870–1914), around 44 years; the Third (1980–2011), around 31 years; and the Fourth is ongoing.

Other estimations don't always agree with this timescale. As late as 2012, The Economist published an article referencing the Third Industrial Revolution while referring to many of the technologies others have come to associate with the Fourth. It's safe to say, then, that history is still being written and it will be many years before we can agree with any accuracy when the Fourth Industrial Revolution actually started.

What we can agree on, however, is that this revolution is founded on us having solved many of the big technological problems of the last few decades; namely faster broadband, better processing power and the improved interoperability of devices across operating systems and platforms. The speed of development at which we've solved these problems has resulted in some truly game-changing innovations.

Technologies such as additive manufacturing, collaborative robotics, artificial intelligence (AI), predictive analytics, and virtual and augmented reality are set to disrupt, challenge and fundamentally change the way human beings work and communicate.

> **“This revolution is founded on us having solved many of the big technological problems of the last few decades”**

However, the pace of change has also divided progress and there are clear leaders and laggards in the race to digitalise. Professional services firm PwC has created an Industry Digitization Index highlighting the relative degree to which digitalisation is transforming various industries. The survey shows that the financial services, electronics, telecoms, automotive and machinery industries have made the most progress, while logistics, consumer goods, real estate and construction lag behind the industry average.

Because different countries are on different points on the journey to digitalise, there is a disparity between the rates of adoption of new technologies, awareness about what the Fourth Industrial Revolution offers, and a cohesive leadership intended to drive change initiatives. This has resulted in a fragmented system, with the concept of industrial digitalisation, or Industry 4.0, referred to by various names including Society 5.0, Smart Industry, Industrie du Futur, Industria Conectada 4.0, Manufacturing USA and Made in China 2025.

What's more, the industrial sector faces a growing challenge from a global technical skills shortage. As well as upskilling those in low-skilled manufacturing jobs, the sector must produce graduates with the relevant digital skills that cover the breadth and depth required in modern industry.

> **“The industrial sector faces a growing challenge from a global technical skills shortage”**

Another common challenge lies in the ability to commercialise; taking ideas and concepts borne of research and development (R&D) initiatives and turning them into profitable projects that provide an attractive source of investment.

Finally, individual projects can only gain traction when supported by widespread support from both industry and government. Although a few countries have put in place national initiatives that have been supported by key policy changes, many are yet to gain such support. This missing leadership will be essential in ensuring the sustained and long-term success of digitalisation.

This book charts the digital journey for manufacturing industries in various countries around the world, looking at the key trends and challenges they face and what they're doing to embrace the future of advanced manufacturing. It also presents interviews with engineers, business leaders and expert commentators on their personal experience of Industry 4.0 and what we can expect to see in the years to come.

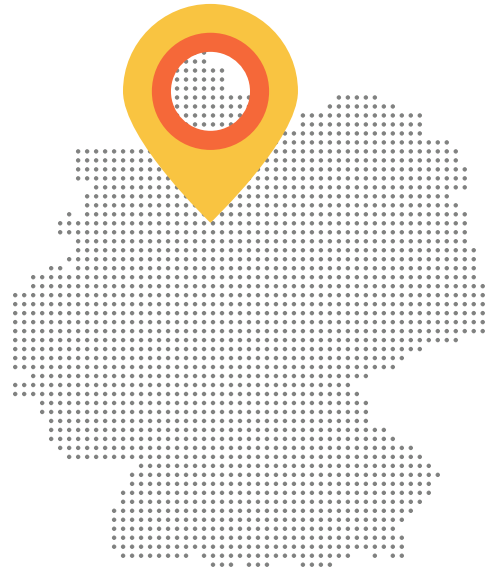
Robotics, artificial intelligence, predictive analytics and virtual & augmented reality are set to disrupt

2

A modern revolution is born

Germany's pursuit to become
the face of a defining industrial movement

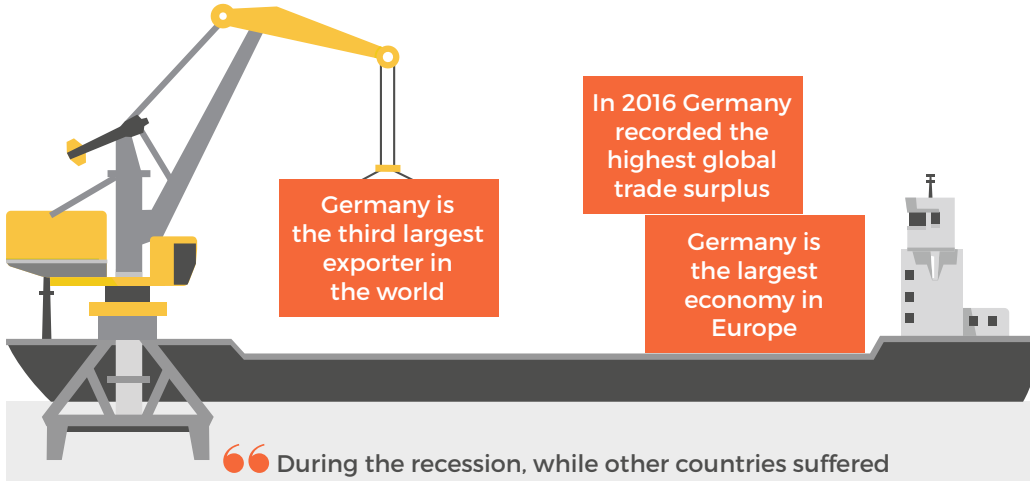
In many ways, it was a trade fair like any other. Except it wasn't. It was Hannover Messe; the world's largest exhibition of industrial technologies. As well as being home to thousands of stands exhibiting the latest and greatest developments in areas such as automation, controls, power and renewable energy, the trade show is also an opportunity to launch new concepts and initiatives.



However, at the Hannover Messe in 2011, three engineers would hold a press conference that would lead to the birth of a modern industrial revolution.

As an industrial nation, Germany is the embodiment of a grade-A student. It boasts the largest national economy in Europe and the fourth largest by nominal GDP in the world. In 2016, it recorded the highest global trade surplus and it is the third largest exporter in the world. Not bad for a country where people work fewer hours and children spend less time in school.

According to a report by the BBC, "When you consider that only the Dutch work fewer hours among the 34 members of the OECD, that German children spend 25% less time in the classroom than their Italian counterparts, and that there are six more productive economies in Europe alone, these facts appear all the more remarkable."



> "During the recession, while other countries suffered high unemployment, German companies were able to exchange reduced working hours for protection against job losses"

There are several reasons behind its success. Germany entered the Eurozone with a trade surplus, giving the deutschmark leverage against the much weaker euro. This in turn boosted German exports, which account for over 41 per cent of GDP. What's more, labour market reforms in 2003 led to a situation where the Government negotiated a moderate wage inflation with labour unions to maintain stability.
This meant that during the recession, while other countries suffered high unemployment, German companies were able to exchange reduced working hours for protection against job losses.

A new vision

And so, it was building on the country's strength and stability that three engineers held a press conference at Hannover Fair in April 2011 to tell the world about their new vision: Industrie 4.0. Here, Dr Henning Kagermann of the National Academy of Science and Engineering (acatech), Dr Wolfgang Wahlster of the German Research Center for Artificial Intelligence (DFKI) and Dr Wolf-Dieter Lukas from the Federal Ministry of Research and Education, explained that being able to assert oneself as a production location in a high-wage region is increasingly becoming a key issue in global competition.

They said that one of the reasons why Germany has been so successful at mastering the economic effects of the financial crisis is because of the development and integration of new technologies and processes. Going forward, this means getting ready for the, internet-driven, Fourth Industrial Revolution.

The three engineers published an article entitled Industrie 4.0: Mit dem Internet der Dinge auf dem Weg zur 4 Industriellen Revolution (Industry 4.0: with the Internet of Things on the way to the 4th Industrial Revolution).

In it, they set forth a vision building on Germany's success in the automotive and mechanical engineering sectors. They wrote:

> **“The digital finishing of production plants and industrial products through to everyday products with integrated memory and communication capabilities, radio sensors, embedded actuators and intelligence software systems, creates a bridge between the virtual 'cyber space' and the real world through to fine - grained synchronization between digital models and the physical reality”**

They explain the advent of a shift away from centralised control over production processes — where engineers have to program machines to turn blank materials into finished products — to an environment where processes use sensors to manage the best way to turn those blank materials into products, "In the industry, this approach leads to a paradigm shift in which the resulting product takes on an active role for the first time. It does not 'centralize' the control, but rather the blank for a product 'says' how it has to be processed in the individual production steps."

This move is further highlighted in a paper published by acatech on cyber-physical systems. The evolution of embedded systems into the Internet of Things, Data and Services can be expressed in four stages. At the bottom, we have embedded systems. These use microcontrollers to carry out a specific task in an electrical or mechanical system; think an airbag, traffic lights, MP3 player or a conveyor system in a factory.

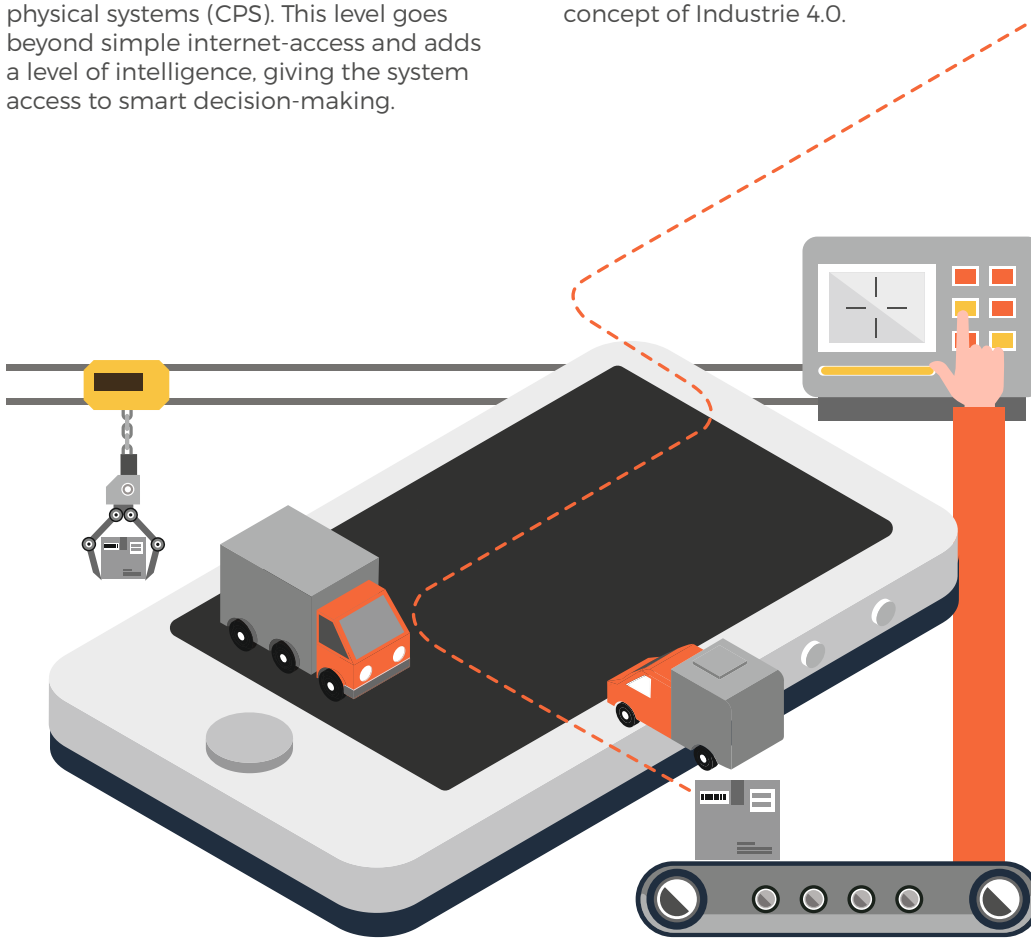
At level two, we have networked embedded systems. This can bring together many discrete areas to achieve complete control over a single system. For example, a programmable logic controller (PLC) allows plant managers to control multiple pieces of machinery and equipment such as boilers, conveyors and chillers with minimal input.

Although level one and two both make use of hardwired connectivity such as Ethernet or Fieldbus technology, they can both combine sensors and wireless protocols such as Wi-Fi and Bluetooth to enable internet connectivity.

Above this, at level three, we have cyber-physical systems (CPS). This level goes beyond simple internet-access and adds a level of intelligence, giving the system access to smart decision-making.

Here, complex algorithms and machine learning are called on to provide a deep link between hardware and software. Different elements of the network work together to deliver efficiency and autonomy. Examples of cyber-physical systems include smart electricity grids, autonomous vehicles, autopilot avionics, patient-monitoring medical systems, factory process control networks and distributed robotics.

Above cyber-physical systems we have level four. Here, all these subsystems are combined into a real-world application such as a smart city. It was this visionary interplay between the IoT, cyber-physical systems and industry that led the three engineers to create the concept of Industrie 4.0.



Industrie 4.0

Even though the concept has now taken the world by storm, the lead up to the first use of the term Industrie 4.0 at Hannover Fair started back in 2006 when the German Government published its High-Tech Strategy. This looked at how the country can become a world leader in research and innovation. It involved the creation of a working advisory group, which was eventually co-chaired by Dr Kagermann and Dr Siegfried Dais of Robert Bosch GmbH.

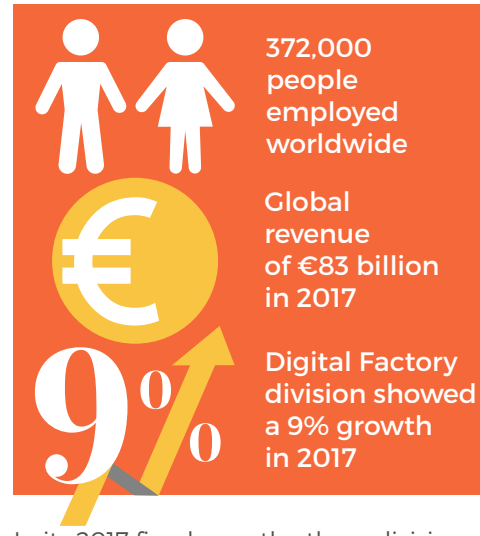
The findings of the group's work on cyber-physical systems, mobility, health, energy and production — along with the launch of Industrie 4.0 at Hannover Fair — prompted the Government to adopt Industrie 4.0 as a 'future project'.

This resulted in the creation of the Plattform Industrie 4.0, a collaboration set up in April 2013 by three private associations for digitalising industry: The Federal Association for Information Technology, Telecommunications and New Media (BITKOM), The German Machinery and Plant Engineering Association (VDMA) and The Electrical and Electronic Manufacturers' Association (ZVEI).

In April 2015, the Plattform Industrie 4.0 was expanded, taking on additional players from companies, associations, trade unions, science and politics. At Hannover Fair in April 2016, The Plattform Industrie 4.0 published its first progress report and continues to make strides in bringing together influential stakeholders in the market to accelerate innovation.

Case in point: Siemens

Siemens is perhaps the best example of a company that has made the transition to digital technologies in a big way. The company and its subsidiaries employ around 372,000 people worldwide and reported a global revenue of approximately €83 billion in 2017. The primary markets for the company are Industry, Energy, Healthcare (Siemens Healthineers), and Infrastructure and Cities.



In its 2017 fiscal year, the three divisions that generated the highest revenue for the company were its Power and Gas division (€15.5bn), its Healthineers division (€13.8bn) and its Energy Management division (€12.3bn). Interestingly, the division responsible for the highest comparative growth in revenue was Siemens' Digital Factory division, which showed a nine per cent rise in revenue (to €11.4bn) compared to the same period in the previous fiscal year.

Whether it's an industrial plant or an office building, Siemens has developed a four-stage roadmap to help customers digitalise. The first step is a scoping workshop where stakeholders can set out their digitalization goals. This is followed by a maturity assessment to gauge the existing level of IT infrastructure and what is required to increase the level of automation. Level three sees the creation of a tailor-made digital road map charting the subsequent three years of automation development. Finally, level four involves putting the digitalisation roadmap into practise, tracking performance and financial return on investment.

In practise, Siemens has used its digital technologies to help companies around the world. For example, Siemens helped Chinese consumer-electronics engineering company Bozhon use digital twinning to reduce its time to market. As consumers increasingly demand the latest smartphone models, the product lifecycle is shrinking and moving to release cycles of twelve months or less.

As a result, manufacturers are trying to find ways of improving their production machinery to maintain quality while increasing output. In an environment where even marginal incremental improvements can mean the difference between the success or failure of a product, manufacturers must engineer their production equipment quickly while maintaining absolute secrecy.

When Bozhon was looking for a way to build an assembly cell with robot arms to join the front and back housing of a smartphone, it turned to Siemens. The objective was to make time savings of 30 per cent, and accelerate the development, delivery and commissioning of new machines at the customer site. Siemens helped Bozhon to create a virtual 3D model of the planned machine to allow the company to simulate the creation of the end product. The intelligence behind it fell to Siemens' open, cloud-based IoT operating system MindSphere, which was able to record and analyse data at every step of the way to deliver predictive maintenance and reduce power consumption.

> One trend that is gaining traction is the concept of modular automation

Siemens explains that, "The digital twin was a fully detailed representation of the actual prospective machine that would allow its sequences of movement to be simulated. The outcome: the entire value chain was comprehensively represented, tested, and optimized in digital form, from product design through planning and designing the machine itself, all the way to the production process and performance."

The company is also making strides in other areas of the smart factory too. One trend that is gaining traction is the concept of modular automation. While the idea of modular design and modular building has been around for years — prefabricated buildings are often used by utility companies to speed up build-times — until now it has not been possible to take this approach to create a production plant.

Christian Schäfer, head of Automation Technology at pharmaceutical, chemical and life sciences company Merck KGaA, explains, "Over the past three decades it went like this: you decided what you wanted to make, and then you ordered a specialized automated plant that would then operate for a number of years. But that doesn't work anymore. The market demands smaller and smaller batches produced more and more quickly. Does that mean you have to build a new production plant for each batch? Impossible, especially for Merck with its small volumes manufactured in the usual high-production facilities. New plants have to be flexible and efficient. Our response to Industrie 4.0 is modularization".

> The market demands smaller and smaller batches produced more and more quickly

Merck's new plant uses modules that can be connected in series, parallel or both. Each module runs a Siemens control system so that it can be operated independently, a backbone allows modules to simply plug-and-play, and a HMI fascia module allows easy input. Each module also contains information that allows the control system to orchestrate the digital connection between various parts of the system.

This programming and software integration is what usually takes the most development time, so by solving the software challenge businesses can cut down on the engineering time required to start manufacturing products.

A crucial aspect of the modular development by Siemens has been its willingness to develop such systems before the necessary industry standards and protocols have been finalised. Mathias Maurmaier, Engineering and Automation Project Manager at Siemens Process Industries and Drives, explains, "We no longer wait until a standard has spent years in a committee being honed to completion; instead, we work in parallel with the committee to develop initial solutions to be used in customer projects".

A model worth copying

The success of the German economy and the global achievement of companies such as Siemens shows just how powerful a fledgling industrial movement can be. A strong economy, bolstered by policy support and funding at a national level, combined with cross-industry collaboration has allowed technological innovation in Germany to flourish — and represents a model worth copying.

The latest trends in automation

Interview with
Neil Mead
editorial director
at Datateam
Business Media

Neil Mead is the editorial director at Datateam Business Media, a modern and dynamic publishing business based in the UK with a comprehensive product portfolio of leading magazines, websites and events across multiple business-to-business sectors. This includes a dozen titles covering different aspects of engineering and manufacturing. Mead's background is in journalism, having worked for a number of different publishers on a range of magazines, from mainstream and special interest consumer products, to more focused and technical publications.

Mead started working in the industrial press as editor of Factory Equipment magazine when he joined Datateam just over 12 years ago. Since then, he has also edited a number of the other magazines within the Connecting Industry branded portfolio and is currently editor of Automation magazine.

> **“Manufacturing still plays an incredibly important role in our country's economy”**

“I have a very keen interest in engineering and technology," explains Mead. "I enjoy learning about how a new product or solution may help to improve a process.

"Manufacturing still plays an incredibly important role in our country's economy, so it feels good to be reporting on and writing about something that really makes a difference. We have witnessed many interesting developments and huge advances in automation technology while I've been editing the magazine over the last ten years, and I'm excited to see what changes are going to take place in the next ten".

EU Automation: As a journalist working in the automation media, you've covered everything from machine technology and robotics, to control systems and Industry 4.0. Of the trends you've seen over the last few years, which will have the biggest impact on industry as we know it?

Neil Mead: Although a lot has been said about technologies such as artificial intelligence (AI) I don't think it has had much impact yet, particularly in solving some of the big problems. It's getting there, but manufacturers are not really switched on to the full potential it offers just yet. I think this will improve as it continues to integrate with Internet of Things (IoT) systems.

As the integration improves, we can expect to see machines use more intelligence, better machine learning and improved algorithms to find the most efficient ways of carrying out repetitive tasks as well as improving production processes without human input.

> **“Manufacturers are not really switched on to the full potential it offers just yet”**

Two technologies at the forefront of many people's minds at the moment are virtual reality (VR) and augmented (AR) reality. In day-to-day use, I see their potential for use in maintenance and training applications. Here, it will eventually become common for maintenance engineers to use AR glasses to overlay instructions and tutorials directly over their field of vision. More immersive VR technology will be useful for training new staff.

Additive manufacturing is another area that has seen lots of discussion in the media. I've seen it mainly being used in product design and in maintenance, repair and operations (MRO) applications. The key to the success of the technology will be in helping companies effectively print their own finished parts. This is already helping businesses in some high-tech sectors, such as aerospace, improve the efficiency with which they create parts, using fewer resources, reducing weight and cutting costs. It will also help because companies will be able to keep parts they need in stock rather than wait on re-orders to arrive.

> **Digital twinning is a technology that I have seen in action making a real difference to the design and manufacturing process**

Digital twinning is a technology that I have seen in action making a real difference to the design and manufacturing process. This allows businesses to generate a virtual 3D model of a plant's processes in real-time and then manipulate this to gain insights — or predict problems ahead of time — without affecting the plant's performance. Engineers can save time and costs by developing a product in the virtual world before committing to any raw material or tooling expense. It also allows development teams to collaborate easily from anywhere and have an input at every stage of the product design process.

However, robotics is the technology that's had the biggest impact on automation to date. While people were initially concerned about its impact on jobs, businesses around the world are increasingly seeing the benefits of using robots and the positive impact they have. Robots are good at things that humans are not, such as repetitive tasks, which means that humans can upskill and actually make businesses more productive, allowing them to hire more people.

Machine vision, combined with better sensing technology, is another trend that's had a significant impact. The rate at which vision systems can read code, automatically identify problems on a production line and deal with them quickly has drastically improved traceability. This is becoming especially important for businesses such as those in the food and beverage sector that can now offer customers traceability 'from farm to fork'. It has also expanded to add intelligence to innovations such as automated guided vehicles (AGVs) that can transport goods around a factory or warehouse.

> **Robotics is the technology that's had the biggest impact on automation to date**

We've seen the concept of Industry 4.0 evolve in the technical media over the last few years too. What started out as a focused discussion around automated manufacturing, is now migrating to areas such as supply chains, procurement, business sales and marketing.

Talk us through what you think the factory of the future will look like.

The digital factory of the future will be full of smart, connected machines that require less human intervention and that can be controlled and monitored remotely. Through the use of sensors, algorithms and software, they will also be able monitor themselves and the process they are undertaking, while constantly adjusting for maximum efficiency and producing data that can be analysed and acted upon by a computer running sophisticated manufacturing execution software (MES). Automated guided vehicles (AGVs) will be used to move raw materials to the production line and finished products into the warehouse and people will be working alongside robots on the production line.

> **“The digital factory of the future will be full of smart, connected machines that require less human intervention”**

But automation technology isn't limited to machinery and the factory floor; in the future we will also see it being implemented throughout the entire supply chain. Receiving orders, raw material purchasing, manufacturing, logistics and even financial transactions will all take place without human intervention. Using software systems and developments such as the blockchain, the entire process can be automated, seamless and highly efficient.

The myth that robots will take our jobs persists in the public consciousness despite evidence that automation will actually create more jobs than it takes away. Why do you think this is and what can be done to change this perception?

The general media might paint the perception that robots will take our jobs, but they're not always focused on the industrial sector, they're often talking about areas such as healthcare or retail. Job losses doesn't necessarily mean staff losses. Why not move those people who lose their jobs to automation into the 'thinking and creating' jobs instead? People will have to get switched-on to the reality that we will have a balanced workforce and that we will work alongside robots.

> **“Job losses doesn't necessarily mean staff losses. Why not move those people who lose their jobs to automation into the 'thinking and creating' jobs instead?”**

It's a social change and so we must have a social change in the way we view robots. For example, China and Germany have already invested heavily in this area. They've accepted that they will have a balanced workforce. As a result, we have no choice but to automate to remain competitive, so people are going to have to get used to the idea of working alongside smart machines and robots. This will not only maximise efficiency and profitability, it will lead to increased wealth and higher employment in the long term.

> **“We must have a social change in the way we view robots”**

What new jobs will automation create – what do you find particularly interesting about them?

As robots take on the mundane and repetitive tasks, people will be released to do more interesting and creative jobs. These upskilled operatives will have the opportunity to take on new roles, such as control engineers, data analysers, system designers and robot programmers to name just a few. All these interesting and highly skilled jobs will offer people the opportunity to develop their careers and provide added value to the organisation.

> “People will be released to do more interesting and creative jobs”

What can companies do to upskill existing workers or in hiring new graduates to reduce the global technology skills shortage?

It's about reaching out to students at a young age, like when they're in primary school, to explain the new opportunities, demonstrate how technology will help and make them excited about a rapidly changing industry. Companies like Renishaw are pretty good at doing this.

Everything we use in our everyday lives had to be made by someone. If you get them young enough and switch their minds on to the technology that makes this possible, as they get older they will want to pursue it. We're not very good at talking to primary school-aged children about what they want to do at a later age. It's important to instil these ideas earlier and talk about them and improve the chances that they'll take up these jobs.

With regards to existing workers, it's important that business leaders manage the upskilling process in a way that gets buy-in from staff. Effectively communicating where the business is heading and how technology will help, will go a long way in ensuring that staff don't feel left behind.

A good training programme is vital for any organisation that wants to retain existing staff and attract new recruits. As more digital technology is introduced, there will be an increased requirement for workers to be trained, upskilled and moved into new positions. Digitalisation will hopefully attract more young people into engineering and manufacturing careers, so investing in automation and technology has the added advantage of making the business an attractive option for graduates looking for an interesting job in a high-tech industry.

How much of what is proposed about Industry 4.0 is hype and how much is real? For example, what technologies are people in the industry actually interested in buying and what is simply a product of over-zealous marketing departments?

There is no doubt that the term Industry 4.0 has been used and abused by some companies as a marketing tool. Professing to offer 'Industry 4.0 ready' or 'IoT compliant' products sounds impressive, but it's what they can actually provide to the end-user that's important. Much of this digital technology isn't new, but what the Industry 4.0 concept has done is bring a number of disparate technologies together in a joined-up offering that allows manufacturers to better understand the features and benefits of digitalisation and smart factory solutions.

Can you give us some examples of any companies that you think are doing particularly exciting or interesting things with digital technologies?

Looking more widely, most automation vendors now have a good digital product offering, with many able to supply a complete range of smart, connected devices and solutions. However, when it comes to implementing and investing in automation technologies, the automotive sector has always led. They've always used more robots than anyone else, had the biggest focus on increasing volumes and led in the pursuit of product quality.

Despite this, others are catching up. The electronics industry, for example, is one of the biggest users of collaborative robots on the assembly line and the food and beverage sector relies on automation for speed and product traceability.

The UK Government's MADE SMARTER review highlighted that low adoption of digital industrial technologies is one of the main reasons why the UK is slow to digitalise. What do you think are the big challenges that companies face in digitalising and how can they improve this?

In my experience, many manufacturers have traditionally been conservative when it comes to capital expenditure (capex) investments, in many cases taking a short-term view and preferring to 'make do and mend', rather than buy new machinery and equipment. But a number of recent surveys by manufacturing and financial organisations have shown this mindset is changing and the industry is waking up to the fact that in order to remain competitive it has to invest in new technology and take a longer-term view.

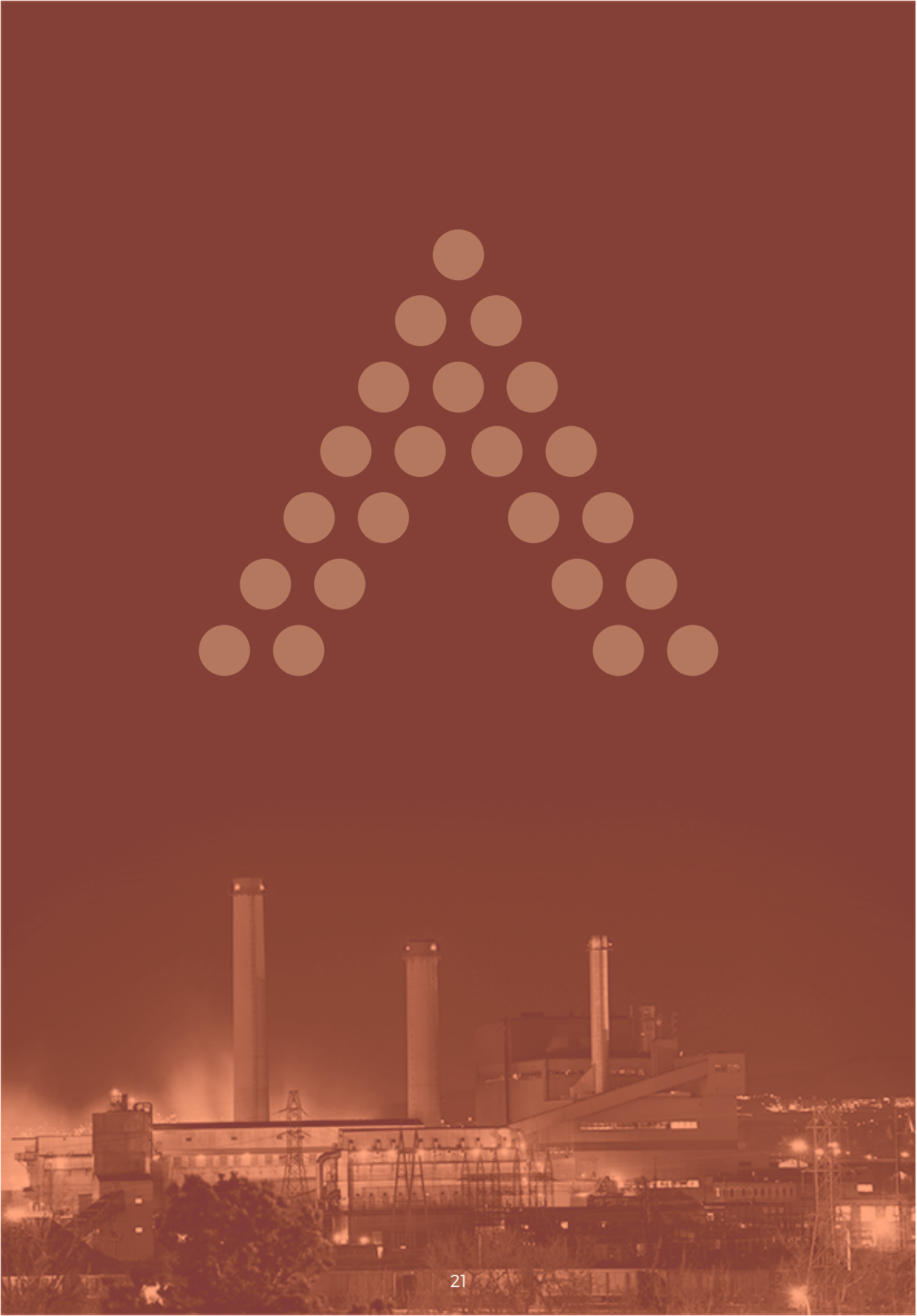
With increased competition, a constantly changing geopolitical picture and the uncertainty caused by Brexit, manufacturers realise they have to invest and automation is key to remaining efficient, competitive and profitable. So, we are starting to see more interest and growth in industry technology investments.

Can you give us some predictions for key Industry 4.0 milestones for the next three to five years?

We've already witnessed huge advances in automation and digitalisation in the last few years and I can't see this slowing down anytime soon. As we move further into the digital age, it's not just the production process that will benefit from this improved connectivity, intelligence, speed and efficiency, but the entire supply chain.

> **“Legacy and obsolete equipment and systems will be updated with retrofit solutions allowing them to benefit from improved connectivity”**

Blockchain and crypto currencies will become better understood, increasingly utilised and more mainstream. Legacy and obsolete equipment and systems will be updated with retrofit solutions allowing them to benefit from improved connectivity. AI and machine learning will become vital tools as we transition from mass production to the mass customisation of products. And collaborative robots will be accepted as valuable contributors to the modern workforce helping us to not only extract the value from Industry 4.0, but also move towards a more human-centric 'Society 5.0'.



4

The home of the Industrial Revolution gets productive

The high growth-potential sectors making waves in the UK

The first industrial revolution began in Great Britain between 1770 and around 1850 and most economists agree that it was a turning point, not only in the history of Britain, but in that of the world.

Writing in The Times Higher Education Supplement in January 2004, economic historian Dierdre McCloskey explains, "in one respect my younger self was disastrously and persistently and ignorantly mistaken. Like half of the contributors to these volumes I was quite sure that 'spirit' had nothing to do with it, that entrepreneurship was a silliness of sociologists, that we can tell the story of modern economic growth by sticking to the virtue of prudence.

"Modern economic growth is the increase of income per head by a factor of 15 or 20 since the 18th century in places like Britain — and a factor of 8.5 worldwide even including the places that have not had the luck or skill to let it happen fully. It is certainly the most important event in the history of humanity since the domestication of animals and plants, perhaps the most important since the invention of language. It bids fair to free us all, eventually."

Spirit, then, is perhaps a commodity that Britain could do with more of. The financial crash of 2008 and 2009 took its toll on productivity and, while it's taken the Eurozone a decade to recover to pre-crash levels, UK productivity still lags. According to the Financial Times, "Britain's productivity growth rate has also improved — from 0.6 per cent last year to a projected 0.8 per cent in 2018 — but that is far behind the 2.1 per cent Britain sustained before the financial crisis".

An industrial strategy

To boost the economy, the UK Government has created its Industrial Strategy to promote growth of future technologies and stimulate the economy. The strategy outlines four 'Grand Challenges' where Britain can lead the global technological revolution:

1. Artificial intelligence and big data
2. Clean growth
3. The future of mobility
4. Meeting the needs of an ageing society

The Government has outlined five areas of policy that will be revamped to put Britain in a better position to overcome these challenges. The policy areas are ideas, people, infrastructure, business environment, and places. Among other things, ideas sets a target of increasing investment in research and development to 2.4 per cent of GDP by 2027. People, focuses on improvements in education, investing £406m in STEM skills and £64m in reskilling and retraining.

Infrastructure will see £400m allocated to electric vehicle charging infrastructure, business environment includes a commitment to roll out sector deals and partnerships and places involves the creation of local industrial strategy initiatives, an intra-city transport fund of £1.7bn and a £42m teacher development pilot programme.

Key policies include:

Ideas
Raise total research and development (R&D) investment to 2.4 per cent of GDP by 2027

Increase the rate of R&D tax credit to 12 per cent

Invest £725m in new Industrial Strategy Challenge Fund programmes to capture the value of innovation

People
Establish a technical education system that rivals the best in the world to stand alongside our world-class higher education system

Invest an additional £406m in maths, digital and technical education, helping to address the shortage of science, technology, engineering and maths (STEM) skills

Create a new National Retraining Scheme that supports people to re-skill, beginning with a £64m investment for digital and construction training

Infrastructure
Increase the National Productivity Investment Fund to £31bn, supporting investments in transport, housing and digital infrastructure

Support electric vehicles through £400m charging infrastructure investment and an extra £100m to extend the plug-in car grant

Boost our digital infrastructure with over £1bn of public investment, including £176m for 5G and £200m for local areas to encourage roll out of full-fibre networks

Business Environment
Launch and roll-out Sector Deals - partnerships between government and industry aiming to increase sector productivity. the first Sector Deals are in life sciences, construction, artificial intelligence and the automotive sector

Drive over £20bn of investment in innovative and high potential businesses, including through establishing a new £2.5bn Investment Fund, incubated in the British Business Bank

Launch a review of the actions that could be most effective in improving the productivity and growth of small and medium-sized businesses, including how to address what has been called the 'long tail' of lower productivity firms

Places
Agree Local Industrial Strategies that build on local strengths and deliver on economic opportunities

Create a new Transforming Cities fund that will provide £1.7bn for intra-city transport

Provide £42m to pilot a Teacher Development Premium. This will test the impact of a £1000 budget for high-quality professional development for teachers working in areas that have fallen behind

We will ensure our Industrial Strategy will endure by creating an Independent Industrial Strategy Council that will assess our progress and make recommendations to the government.

Source: UK Industrial Strategy

One of the headline features of the strategy is the UK's focus on becoming a world leader in artificial intelligence. This was highlighted in prime minister Theresa May's speech at the World Economic Forum's 2018 annual meeting in Davos, Switzerland, where she introduced the UK's Industrial Strategy. Here, she talked about how technology is changing in ways we could only have imagined a few years ago. She gave the example of how a drone had saved two boys from drowning off the coast of Australia by delivering a floatation device to them.

> **“One of the headline features of the strategy is the UK's focus on becoming a world leader in artificial intelligence”**

She also explained how AI will transform healthcare, citing a recent test where machine learning had been used to reduce the number of unnecessary surgeries for breast cancer by a third. Another example was how AI will protect companies from money laundering, fraud, cybercrime and terrorism.

Coming to the UK's role in AI, May said, "Already the UK is recognised as first in the world for our preparedness to bring artificial intelligence into public service delivery. We have seen a new AI start-up created in the UK every week for the last three years. And we are investing in the skills these start-ups need, spending £45 million to support additional PhDs in AI and related disciplines and creating at least 200 extra places a year by 2020-21. We are absolutely determined to make our country the place to come and set up to seize the opportunities of Artificial Intelligence for the future."

A thriving manufacturing sector

Despite an overall fall in economic productivity, the UK manufacturing sector is thriving, but it will be the potential growth of the sector and its use of digital technologies that will ensure the success of wider digitalisation.

The UK has a particularly strong competency in advanced manufacturing sectors such as aerospace, pharmaceuticals, food and beverage, fintech and construction. This stems from the UK's historic lead in research and development, product design and high-end manufacturing. MADE SMARTER, the UK Government's independent review of industrial digitalisation, pegs industries such as aerospace, automotive, pharmaceutical and construction as having high growth potential.

Of the construction sector, for example, it says, "The scale of the opportunity is in both the unique nature of construction (its size and vital role in the economy) and its potential to be a high value digital industry that is the foundation of a digital economy. Digitalisation will enable the sector to deliver services cheaper, faster and smarter".

According to a report by
UK trade magazine The Manufacturer,

“Manufacturing contributes
£6.7 trillion to the global economy.
Contrary to widespread perceptions,
UK manufacturing is thriving,
with the UK currently the world's
eighth largest industrial nation.
If current growth trends continue,
the UK will break into
the top five by 2021.

In the UK, manufacturing makes up:
11% of GVA (Gross Value Added),
44% of total UK exports,
70% of business R&D,
and directly employs
2.6 million people.”

The results of a survey carried out in The Manufacturer's Annual Manufacturing Report 2018 show that most UK manufacturers now accept that "the future of (successful) manufacturing lies in the adoption of advanced largely digital technologies". However, fewer than ten per cent of respondents said that they found it easy to access finance to fund new digital technology purchases. The problem is that even where they have the cash to invest, there is a reluctance to spend it on technologies that will improve productivity and profitability because of their sentimental concerns surrounding uncertainty.

> **"The positive impact of faster innovation and adoption of industrial digital technologies (IDTs) could be as much as £455 billion for UK manufacturing over the next decade"**

Reluctant progress

It is this reluctance to pull the trigger that is holding the UK back. MADE SMARTER found that, "the positive impact of faster innovation and adoption of industrial digital technologies (IDTs) could be as much as £455 billion for UK manufacturing over the next decade, increasing manufacturing sector growth between 1.5 and three per cent per annum, creating a conservative estimated net gain of 175,000 jobs throughout the economy and reducing CO2 emissions by 4.5 per cent. Overall, from the data and evidence collated, we are confident that industrial productivity can be improved by more than 25 per cent by 2025."

However, the report also says that there are three major problems preventing the UK from fully achieving this vision. These are a lack of effective leadership, poor levels of adoption of IDTs and an under leveraging of innovation assets.

1

In the first problem, the report argues that, "there is no clear narrative setting out what the UK already does well..." that, "there is no cross-sector national leadership providing market-focused strategic vision..." and that, "without a clear vision and narrative the UK is failing to inspire current and future workers".

2

On the second problem, the report explains that one of the reasons why the UK's productivity is lower than other advanced nations is its lower levels of adoption of digital and automation technology, particularly among small and medium sized enterprises (SMEs).

3

In the report, the analysis of the third problem looks at why the UK is a leader in research and innovation and how it has improved its ability to develop and commercialise technology but struggles to use these 'innovation assets' to support new IDT start-ups and help businesses scale up.

The report goes on to make four recommendations — split into thirteen parts — to solve these problems. For example, the first one recommends, "creating a much more visible and effective digital ecosystem to accelerate the innovation and diffusion of Industrial Digital Technologies". It proposes investment in a new National Adoption Programme (NAP) to kick-start funding and offer the mentoring required to accelerate the diffusion of IDTs. It also proposes scaling up the support provided by the UK's Innovation centres – a network of Digital Innovation Hubs (DIHs) located around the country.

Catapult to success

The Catapult centres, as they're known, are a network of research and development facilities established by Innovate UK, formerly known as the Technology Strategy Board — setup by the Government in 2004 and rebranded in 2014. The centres are located strategically around the UK and focus on delivering R&D in areas such as high value manufacturing, cell therapy, offshore renewable energy, satellite applications, transport systems and future cities.

The results of the network over the last few years have been positive. Companies like Volvo and Nissan have brought autonomous vehicle R&D programmes to the UK, cell and gene therapy firms have given the UK a seven per cent share in the global market and the manufacturing sector is attracting venture capital funding from around the world, including the likes of McLaren, which has announced plans for a £50m investment in Sheffield.

So, despite some roadblocks, the UK is in a very good position to take advantage of the growth in digital. By maintaining this progress and overcoming the barriers — and simply being less reluctant to adopt new technologies — the UK can once again bring home the Industrial Revolution.

5

A pan-EU tour of Europe

A review of the main European digital initiatives

Compared to other regions, Europe has perhaps the densest concentration of digital transformation initiatives anywhere in the world. Progress varies a lot by country across the continent and the obvious candidates are not necessarily the ones that have made the most progress. While countries like Germany, the UK and France have done well, it's actually Denmark, Sweden and Finland that have scored the highest in terms of digitalisation.

> **"The top four EU countries Denmark, Finland, Sweden and the Netherlands are among the global leaders"**

The European Commission's Digital Economy and Society Index (DESI) 2018 is one of the leading measures of the progress that EU countries are making towards the digital economy. It looks at five areas: broadband connectivity, human capital and skills, how citizens are using the internet and the extent to which companies have integrated digital technology into their businesses.

The report showed that in 2017, Denmark, Sweden, Finland, and the Netherlands had the most advanced digital economies, followed by Luxembourg, Ireland, the UK, Belgium and Estonia. In the report, Ireland, Cyprus and Spain had progressed the most over the last four years all improving by more than 15 points. At the other end of the scale, the lowest increase in digital performance of below ten points, was recorded in Greece.

The international version of the DESI report analyses Europe in an international context and concludes that, "The top four EU countries (Denmark, Finland, Sweden and the Netherlands) are among the global leaders. They are just behind Korea and have higher scores than the United States and Japan. At the same time, however, the comparison shows that the EU's average in digital performance is significantly lower".

The factors that set apart the leading countries are things like access to funding, both public and private. Aside from financial offerings, there is also a focus on helping both small and large organisations to develop and policy levers to incentivise the adoption of digital technologies and attract private investment.

Some programmes are top-down in their approach with heavy intervention from governments. Others take a more organic, bottom-up approach seeking help and direction through wider collaboration with academic institutions and research organisations.

> **"The factors that set apart the leading countries are things like access to funding"**

Many European countries face common barriers such as the technology skills gap, a lack of funding and initiatives not backed by policy changes. Overcoming these has a great impact on the results that countries have achieved, ranging from an increase in funding, higher levels of technology adoption and better awareness among domestic businesses about the help available to them through the schemes.

Europe as a whole

The European Commission launched the Digitalising European Industry (DEI) initiative in 2016, which set out its aim to strengthen Europe's position on digital technologies. As well as maximising the impact on innovation, growth and prosperity in Europe, the policy was designed to eliminate the risk that, if Europe didn't attract foreign investment, the money might go elsewhere.

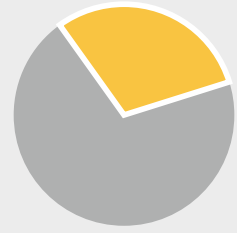
The initiative is focussed around 'innovation platforms' intended to direct research towards connected smart factories, smart agriculture and the digital transformation of health care, industrial data and the Internet of Things (IoT). The group brings together political and industrial leaders, mobilises national initiatives and shapes national strategy.

As a result of the DEI's work, 15 national initiatives on digitalising industry have been launched around Europe. While significant progress has been made across the EU with regards to entrepreneurial culture, supply and demand of skills, investments and access to finance, improvements are still needed by many eastern and southern European states.

According to the report, 57 per cent of companies believe they have the necessary skills to adopt new digital technologies. 27 per cent of European businesses in the food industry and 10.7 per cent of those in construction have appointed a chief digital officer (CDO). More than 70 per cent are interested in digital technologies that can improve production processes.

57%

Of companies believe they have the necessary skills to adopt new digital technologies



27%

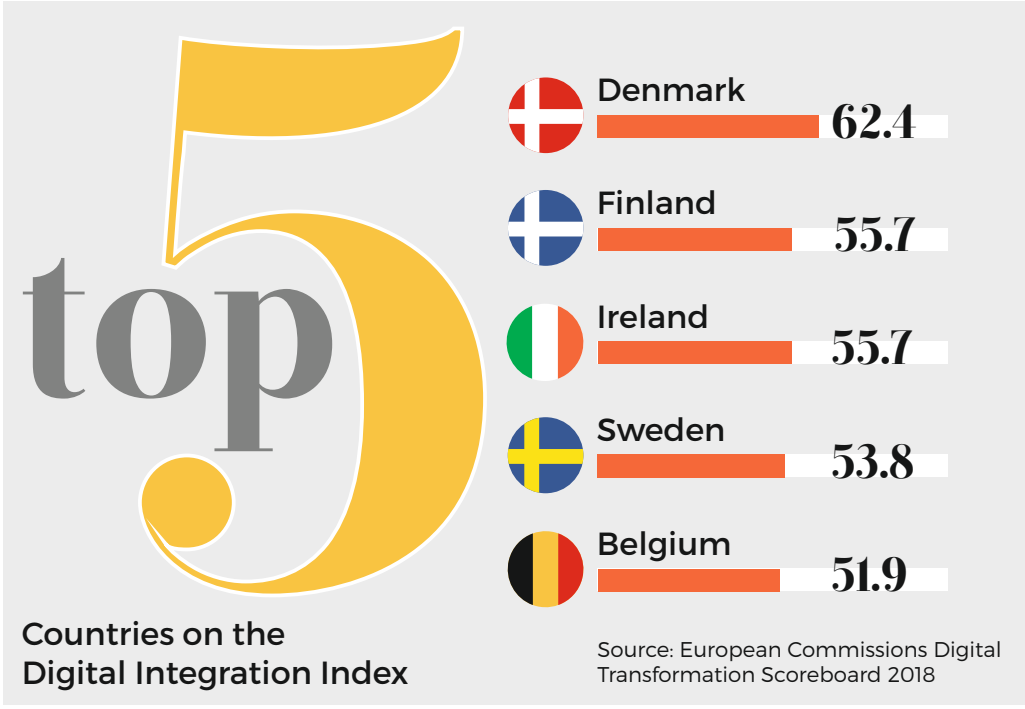
Of European businesses in the food industry have appointed a chief digital officer

10.7%

Of European businesses in the construction industry have appointed a chief digital officer

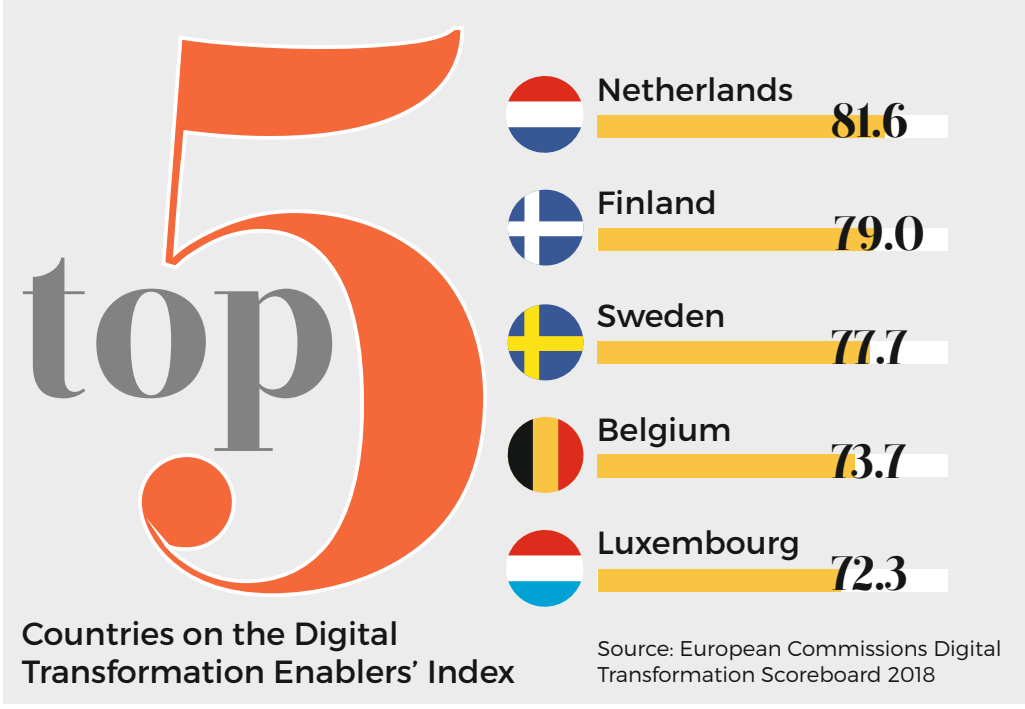
70% plus

Are interested in digital technologies that can improve production processes



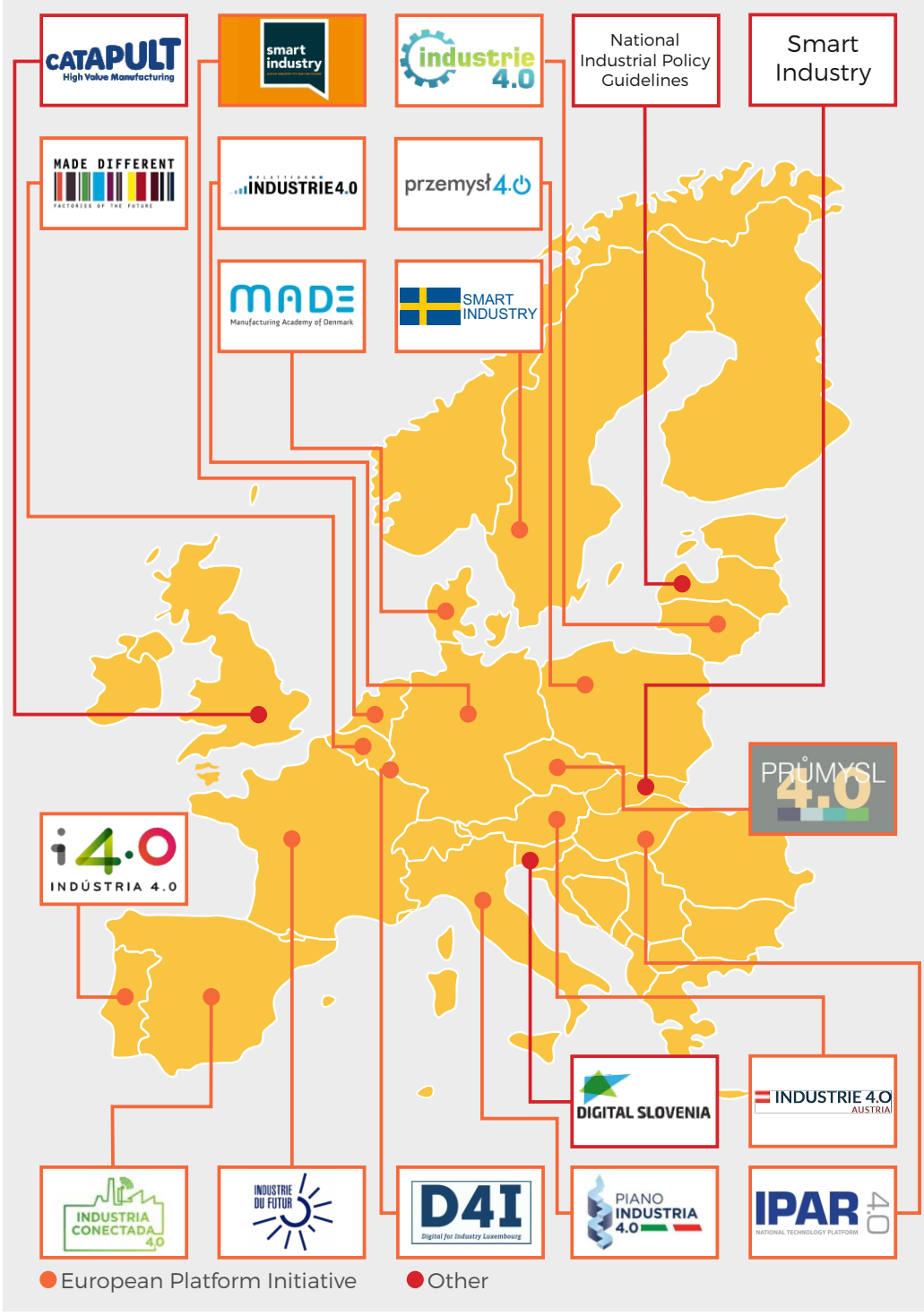
Countries on the Digital Integration Index

Source: European Commissions Digital Transformation Scoreboard 2018



Countries on the Digital Transformation Enablers' Index

Source: European Commissions Digital Transformation Scoreboard 2018


CATAPULT
High Value Manufacturing
smart industry
industrie 4.0
National Industrial Policy Guidelines
Smart Industry
MADE DIFFERENT
FACTORIES OF THE FUTURE
INDUSTRIE4.0
przemysł 4.0
MADE
Manufacturing Academy of Denmark
SMART INDUSTRY
PRŮMYSL 4.0
i4.0
INDÚSTRIA 4.0
DIGITAL SLOVENIA
INDUSTRIE 4.0
AUSTRIA
INDUSTRIA CONECTADA 4.0
INDUSTRIE DU FUTUR
D4I
Digital for Industry Luxembourg
PIANO INDUSTRIA 4.0
IPAR 4.0
NATIONAL TECHNOLOGY PLATFORM
European Platform Initiative
Other

Most member states show a high level of acceptance and interest in cybersecurity, blockchain and artificial intelligence. While analysis of the media shows that positive sentiment of these technologies is high, actual adoption is still low. Fewer than 35 per cent of respondents to the DTS survey have adopted at least two of the nine key technologies, which we've covered later on in the book.

The survey of 120 companies across Europe shows that a firm's size, age and stage of development makes a difference to how it adopts technology. Smaller firms are more likely to adopt a specific technology than larger firms. This is evident from the fact that nearly 75 per cent of companies with fewer than ten employees have adopted at least one digital technology for business purposes compared with half of firms with more than 250 employees.

> **“Most member states show a high level of acceptance and interest in cybersecurity, blockchain and artificial intelligence”**

Young firms, under five years old, also have a higher rate of adoption compared to those aged 10–15 years or older. The same goes for stage of development. 100 per cent of start-ups are using at least one digital technology, even though they make up a much smaller share of the market. Domestic firms show the lowest level of adoption (47 per cent) and internationally-recognised firms are better than this (67.5 per cent).

The business functions that were the most affected by technological adoption were operational marketing, CRM, quality assurance and project management. The factors least affected by technology adoption were technical and enterprise architecture and strategic partner management.

This makes sense; after all, digital technologies are designed to improve efficiency, quality and output while leaving the more creative decision-making to human minds. Although, as analytics programmes become more powerful at making sense of large volumes of process and business data, better insights will allow leaders to make better, more timely decisions. We can expect these factors to become more important when businesses are considering digital technologies.

Looking at initiatives across Europe, it's not necessarily true that the larger the country, the more funding is available from government. Different governments have invested different amounts over varying periods of time. For example, the market for Industry 4.0 in Germany was estimated to be worth €7bn in 2018 and the total amount of funding committed by the German Government is €200m. Italy's Industria 4.0 has committed more than €18bn from 2017 to 2020 and France's Alliance Industrie du Futur has assigned €10bn. It's easy to see that funding is only one indicator of the success of any initiative. Other areas include tax incentives, fiscal policy designed to attract private investment and support for R&D from public and private companies.

A digitalisation travel guide

To highlight some of the interesting ways in which governments are thinking about the future of industry, here is a roundup of seven European countries and their journeys to digitalisation.

Belgium MADE Different

Belgium ranks eighth on the Digital Economy and Society Index (DESI). The Index measures characteristics such as the connectivity of fixed and mobile broadband in the country, human capital and digital skill level and how well integrated technology is in business.

The country's aim is to use the Made Different initiative to turn manufacturing companies into factories of the future. Instead of using a top-down approach like Germany, Belgium's initiative is not funded by Government and is an industry-driven programme that has relied on events, guidance services and annual awards to raise awareness and buy-in. The programme has had success in the Flanders region and is growing in Wallonia.

The key focuses for the campaign are based on, "a strong innovation and design competence, customer orientation and networking, energy and material-efficient technologies and creative human potential".

Interested companies can use an online app to complete a survey, telling them the type and extent of transformations they need. Made Different representatives can then help them to complete a half-day site survey for further help, with the implementation phase taking up to two years to complete.

Made Different has done well at helping small and medium sized enterprises (SMEs), which make up 98 per cent of all manufacturing companies. SMEs are usually the ones that need the most help, so this is reassuring to see. However, dedicated funding is still required to drive momentum of the programme further.

> "The country's aim is to use the Made Different initiative to turn manufacturing companies into factories of the future"

Pros

- Ranked eighth on the DESI Index
- Factory of the Future (FoF) Awards help companies attract investment
- SMEs benefit from bottom-up approach, which provides individual guidance
- 265 companies have benefited, 16 companies have received FoF label

Cons

- No specific state funding for manufacturing companies
- Companies need to carry the cost of digitalising

Denmark MADE

MADE, which stands for Manufacturing Academy of Denmark, is a collaboration between Danish manufacturing companies, five of the country's universities and three research and technology organisations (RTOs). The aim is to improve people's knowledge of innovative manufacturing techniques to make the country more competitive.

It's a bottom-up programme like Belgium's but the key difference is that it's funded by the Government as well as the private sector, with the budget totalling around €50m from 2014 to 2019.

Denmark is good at giving practical help to companies too, whether that means arranging laboratory visits, hosting innovation conferences or workshop visits to the likes of children's toy manufacturer Lego. Here, visitors can learn about areas such as product customisation, hyper-flexible robots, 3D printing and data analytics.

The Danish Government took a light touch approach with MADE. It didn't intervene a lot, leaving academia and industry to define the development of the programme. Although this was a high-risk approach, it gave the country some big results. 15 companies participating in the advanced projects reported revenue increases of €135,000 and collective savings of around €5.5m.

The project's success has even garnered interest from Korea, which is now looking to mimic MADE. At the same time, Denmark faces two barriers: ensuring that the public and private partners continue to work for the benefit of the country and securing long term funding.

“Visitors can learn about areas such as product customisation, hyper-flexible robots, 3D printing and data analytics”

Pros

- Denmark ranked first on the DESI Index and has allocated €24.1m
- The industry is good at arranging lab visits, conferences and workshops
- 34 innovation activities, 44 industrial projects, 15 cluster projects for SMEs

Cons

- Denmark still has to tackle the trend for offshoring due to high domestic salaries
- The platform needs better long-term funding instead of relying heavily on grant applications

France Industrie du Futur

France's Industry of the Future Alliance (IdFA) has built the programme on five pillars: cutting edge technologies, business transformation, training, international cooperation and promotion. Before the Government invested €10bn into the programme, companies struggled to modernise with the right production tools.

Industrie du Futur has done well at tackling the traditional uneven deployment of digital technology across different regions of the country. With the help of management consultancy McKinsey, the French Government has focused on developing advanced manufacturing in theme-based industry areas such as transport, IoT, medicine, security and sustainability. Each of these areas has its own roadmap, objectives and timetable. This approach will ensure that no one area or region receives funding and attention at the cost of others.

For example, the IdFA's research into virtual plants of the future looks at the development of autonomous sensors. These next generation sensors harvest the energy around them from solar, vibrational and thermal energy to power the sensor.

Autonomous sensors also use the latest encryption protocols and materials such as electroactive polymers that can change shape when an electrical current is applied. This is useful for handling extreme environments where the sensor could compensate for rapid fluctuations in temperature, humidity and pressure without intervention or recalibration by a person.

France faces two main digitalisation challenges. First, it needs to ensure that it can control the even funding deployment of the programme at a regional level. As well as this, there is a gap between the skills industry possesses and the digital skills needed. This can be overcome by offering some certainty about how people's jobs will change and the training that will be offered.

Pros

- 3,400 companies identified to participate in production modernisation
- 300 experts identified across 18 regions
- Loans provided to over 800 companies

Cons

- Funding not always deployed evenly at a regional level
- A skills gap between the skills industry needs and qualifications

Italy Industria 4.0

Italy's Industria 4.0 is a programme still very much in its infancy, having only been launched in February 2017. It was inspired by similar Industry 4.0 initiatives in Germany, France and the Netherlands. The Government has earmarked €18bn in a top-down approach that ties in with its equally new industrial policy, the 2017 Budget Act, which brought digitalisation into the public limelight.

As well as improving internet speeds through its Ultra Broadband Plan and creating standards for IoT protocols, the programme wants to attract investment through venture capital and private equity funding. Industria 4.0 has two focuses, one is to help companies transform digitally and the second is to develop skills through digital innovation hubs. The skills development strategy will include I4.0 competence centres, supporting education programmes, vocational training and industrial PhDs in Industry 4.0 subjects.

Italy has done well to offer tax incentives too. Companies looking to invest in industrial digital technologies can benefit from tax breaks — for up to 150 per cent of the value of the asset — for capital investment in technologies that are subject to hyper depreciation. Similar breaks have also been developed for intellectual property rights (IPR) and for SMEs. This is complemented with tax credits worth up to 50 per cent of the cost of R&D activities.

Despite its infancy, Industria 4.0 has been received well. The number of orders placed by manufacturers who acquired new machinery and technologies in the first quarter of 2017 increased by 22.2 per cent, followed by 28.5 per cent in the second quarter. 30Mbps broadband is expected to roll out to all Italian companies by 2020.

> “Industria 4.0 has two focuses, one is to help companies transform digitally and the second is to develop skills through digital innovation hubs”

Pros

- An expected increase of €10bn in private investment in 2017/2018
- 200,000 academic students and 3,000 managers expected to qualify in I4.0

Cons

- Still a new programme finding its way – will take time to deliver results
- Top-down approach relies on interest and buy-in, especially from SMEs

Netherlands Smart Industry

The Government explains that Smart Industries are, "industries that have a high degree of flexibility in production, in terms of product needs, volume, timing, resource efficiency and cost, being able to fine tune to customer needs and make use of the entire supply chain for value creation. It is enabled by a network-centric approach, making use of the value of information, driven by ICT and the latest available proven manufacturing techniques".

Automotive manufacturer VDL NedCar is one company that has benefited from Smart Industry. The company created the concept of a 'warehouse-on-wheels', where assembled parts that are usually stored in a warehouse are instead kept on trailers, eliminating the need for a buffer of automotive parts. To do this, the company used a highly collaborative software system that transparently shows all the orders in the supply chain.

> "The company created the concept of a 'warehouse-on-wheels'"

VDL NedCar explains that suppliers can easily align stock with the OEM's needs and that, "From the moment the supplier receives the pull message via Electronic Data Interfacing, a trailer can be loaded with just-in-time or just-in-sequence deliveries. As a result, the customer order now drives everything. The assembly plant or the supplier is no longer dependent on static forecasts; the assembly plant and supplier are no longer disconnected. Instead, the activities of both assembler and supplier work smartly in unison".

Pros

- Government supported field labs, each with a turnover anywhere up to €4m
- A budget of €25m from 2014 to 2017
- Good involvement of industry, universities, research partners and public sector

Cons

- Low programme budget. An increase is necessary for long term success
- Better focus on process innovation is required

Portugal Indústria 4.0

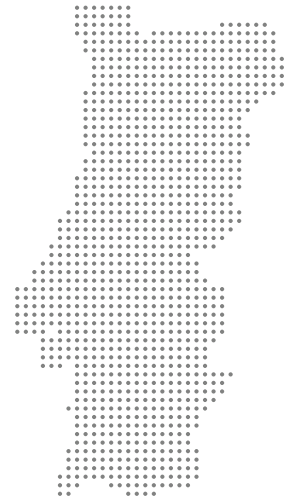
Portugal's Indústria 4.0 stands out from other European programmes in two ways. Firstly, it mostly targets SMEs. Secondly, whereas programmes in other countries have focused predominantly on rapid innovation in new technologies, Indústria 4.0 has a strong focus on upskilling human capital.

The programme emphasises the need for a requalified labour force. One of the priorities is to adapt the education system to match the future needs of the industry by integrating digital skills into the curriculum. It also prioritises employee training and enhanced continuous training using extracurricular activities. Through the Digital Skills Programme the Government aims to train 20,000 people in ICT skills by 2020.

Although the programme only launched in 2017, the Portuguese Government spent ten months working with over 200 companies — 120 of which were SMEs — to develop the strategic plan. This plan will see 60 measures put into place over the next four years at a cost of €4.5bn. As well as loans and tax deductions, SMEs will also be able to apply for vouchers of €7,500 each to help their digital transformation.

The programme's organisers have also launched Platform I4.0, an online interface where people can login to access a repository of knowledge and track the progress of their own change initiative.

As well as putting in place a better mechanism to generate private funding, many people in Portugal are also wary of increases in unemployment because of digitalisation. The cultural barrier will have to be addressed if the programme is to succeed.



> “The programme emphasises the need for a requalified labour force”

Pros

- Bottom-up approach is tailored to the needs of Portuguese companies
- SMEs can apply for vouchers of €7,500 to help with digitalisation

Cons

- Better mechanism needed to generate private-sector funding
- The cultural fear of unemployment due to digitalisation needs to be addressed

Spain Industria Conectada 4.0

One of the biggest problems that Spain wanted to tackle with Industria Conectada 4.0 was the widespread lack of awareness about digitalisation. Simply mimicking schemes from other countries would do little to drive change if there was no interest or appetite to adopt new technologies in Spain itself.

To achieve this, the Government established a public and private partnership that saw collaboration between three groups. The, "strategic group of private partners was set up composed of the Santander bank providing the digital financing knowledge, Telefonica as the telecommunications partner and Indra as the technological consultancy managing the work".

When the programme launched in 2016, the Government allocated €97.5m in loans for innovative research projects targeting industrial enterprises, €68m in the form of loans and direct aid for ICT companies and €10m for innovative clusters.

Because Spain wants to create an identity for its initiative as one that meets the needs of every business, Industria Conectada 4.0 has a heavy focus on helping SMEs and micro-businesses.

A micro-business according to the EU definition is one that typically employs fewer than ten people and whose turnover is less than €2m. For these businesses, a low cost of entry into the market is vital. Because many small businesses start with just a few thousand Euros of capital, access to powerful internet technologies can make all the difference. Here, the programme offers four types of project funding to SMEs and micro-enterprises.

Industria Conectada 4.0 is still in its early stages and so it will take time before awareness and buy-in from all stakeholders ensures its long-term success.

> **“Simply mimicking schemes from other countries would do little to drive change”**

Pros

- There is a strong support for SMEs and for microbusinesses
- Innovation and research programme established in 2016
- €68m in loans and direct aid, €10m for innovation clusters

Cons

- Raising awareness is still an issue
- Could have stronger participation from private sector

Calais Port Expansion

uses lidar coastal mapping technology

When one of Europe's busiest ports announced its expansion seaward, the contractor responsible for building it turned to lidar technology for help. Calais port in France is one of Europe's busiest ports and accommodates annual passenger traffic close to 10 million people. Having awarded €675 million for a two-phase land reclamation project to expand the port and build an access channel for ships, the Nord Pas de Calais Regional Council selected contractors to carry out the work. The world's largest dredging company, Luxembourg based Jan De Nul Group, was selected to carry out the ground work phase of the project.

As part of the land reclamation, Jan De Nul constructed a 3.2km breakwater, a curved structure designed to create an enclosed harbour for ships to dock safely. Here, Jan De Nul needed a way of taking topographical measurements of the coastal terrain to accurately and safely build the structure. Speed was of the essence, as delays in constructing the breakwater can lead to tidal forces damaging the structure before it's finished, meaning that it must be built again.

To solve this problem, Jan De Nul used Merlin, a vessel-based lidar system capable of producing a detailed 3D scan of the breakwater. In a case study published online, Mike Lycke, Jan De Nul Group's Project Survey Manager at the Calais site explains how important this technology was to the success of the project:

“Surveying the underwater terrain has never been a problem because we use multibeam sonar technology mounted onto a survey vessel. However, the part above the water has always been difficult to survey. The breakwater is made up of layers of rock, starting with small ones on the seabed, rising to rocks weighing up to four tonnes at the top of the breakwater.

Traditionally, carrying out a topographical survey was a dangerous manual process. It involved a person climbing onto the slippery rocks with a total station and taking measurements by hand. The only protection was a life jacket, and the process could take up to 12 hours. Even then, the survey data was crude and resulted in slow progress.

Merlin is perfect for our measurement needs, producing high-quality, reliable data despite the demanding marine environment. New users find it easy to operate and, during initial trials, Merlin easily handled wave heights of 1.5m and speeds of six knots at a distance of 75m from the breakwater, producing a high-resolution scan of the accropodes and other complex vertical structures. Merlin easily calibrates with our existing sensor hardware and on-board software, outperforming other conventional and photogrammetric measurement tools”

The data generated by the scanner can be streamed in real-time directly from the vessel to the offices on the port. This means that a 3D model of the coastal structure can be generated in minutes rather than hours.

Interview with Steve Ward, Application Engineer (AE) Director at GE

The smart revolution

Steve Ward is Application Engineer (AE) Director at GE's Automation & Controls division, which forms part of GE Power. In his current role, he leads a team that covers Europe, the Middle East and Africa (EMEA) and he also acts as a pre-sales consultant.

Having qualified with a BA (Hons) in Computing and Systems and, subsequently, an MSc in Information Systems Management, Steve has spent the last 36 years working in the industrial automation space, with equipment such as programmable logic controllers (PLCs), input / output (I/O), distributed control systems (DCS), human-machine interfaces (HMIs) and supervisory control and data acquisition (SCADA) and manufacturing execution systems (MES), all of which fall under the umbrella of the Industrial Internet of Things (IIoT).

In addition to maintaining and supporting the core business in EMEA, Steve is working on the launch of new automation and controls products, growing sales by 30 per cent, including in equipment such as variable frequency drives (VFDs), safety control systems, outcome optimising controllers including Linux controllers and new industrial PCs and displays.

EU Automation: Automation and control systems play an increasingly critical role in society, from the transport systems used by millions of people every day to the water treatment programmes designed to deliver clean drinking water. GE is responsible for automating the processes that generate half of the world's electrical power. How have automation and control systems adapted in recent years to keep up with this demand?

Steve Ward: At its heart, a control system is effectively a computer like any other. The revolutionary changes we've seen in control systems in the last few years have been made possible because of the changes to standard computers. These include things like reductions in size, lower costs and more computing power. Many automation processes are not inherently complicated, and because costs are coming down, people are using automation controllers in wide and varied applications.

> **“Where these applications would have traditionally used fixed motors with simple on and off controls, they can now be networked together”**

One example of this is in conveyor systems. Whether it's a conveyor on a production line in a plant, or a moving walkway used by people in airports, the movement is delivered by electric motors. Where these applications would have traditionally used fixed motors with simple on and off controls, they can now be networked together and use more sophisticated control systems.

Historically, these systems were networked using legacy fieldbus protocols such as PROFIBUS. The problem was that these proprietary protocols required special connections and cables, and simply weren't easy to install or cost effective. As a result, most industrial users have moved to industrial ethernet connections.

Ethernet is a widely used connection protocol, which uses the same underlying technology as the Ethernet technology used in offices and homes around the world. The benefit is that we can now run industrial protocols on these connections and use computer software running on a laptop — rather than the cumbersome handheld terminals that were previously required — to configure the send and receive functions of each device.

The result is a system that is versatile for use in a variety of applications. Going back to our conveyor example, this means that we can bring in intelligent functions that can reduce demand power by automatically starting up and shutting down the conveyor when it's not in use.

> "As users step onto pressure plates in front of the walkway, the system can start moving automatically"

As users step onto pressure plates in front of the walkway, the system can start moving automatically. This is a great way to reduce energy use and also helps to reduce unnecessary wear and tear on the equipment. This, in turn, reduces the downtime associated with the inevitable maintenance and repair costs.

We know that motors wear out and conveyors eventually fail. Usually, this would involve scheduled inspections to check the condition of parts, which would then be replaced as they fail. The benefit of intelligent devices is that they can use sensors to collect data on how the device is performing.

This can help us to predict a device failure, before it occurs. By using advanced algorithms, we can measure anomalies, such as excessive current and voltage use, as well as things like operating temperature and vibration. This gives us the ability to predict future problems and we can send out engineers to replace a part that might be working today but could fail in a few days' time.

Moving to a predictive model not only reduces unplanned downtime, it also reduces unnecessary maintenance costs and allows businesses to focus on what's important; adding value to their processes.

> "Using advanced algorithms, we can measure anomalies, such as excessive current and voltage use"

What trends have you experienced in the way IIoT devices have changed factory automation? For example, how has edge computing expanded the reach of individual plants?

In many ways, the manufacturing industry is still very conservative. Although some sectors are open to change, others are unwilling to try out new technologies. The automotive industry is an example of a sector that has always adopted new technologies.

Automakers were big early adopters of robotic technologies. They connected them using HMIs, which sent data back to SCADA systems that carried out control functions. The data generated by the factory processes were then stored in historian databases and used to analyse trends.

However, this type of architecture creates limitations as to how well you can integrate new technologies such as robots. If operators wanted to access information about how the technology was performing, they would have to go to centralised control rooms, which might be impractical and time-consuming in a large automotive plant spanning millions of square feet.

> **“One trend we've seen with internet-connected devices, is the shift away from a centralised control paradigm”**

In terms of edge computing, one trend we've seen with internet-connected devices, is the shift away from a centralised control paradigm. Data that was previously only available from HMIs and control rooms is now being published directly to mobiles and tablet devices. It can be accessed immediately from remote locations, and engineers can choose to receive e-mails and SMS alerts as soon as the system detects a problem. On the server side, we've seen the development of web-based HMIs and reporting tools that are also providing flexibility through the cloud.

How has the way that process and machine data is interrogated and analysed, changed in the last few years?

In an attempt to reduce capital expenditure (CAPEX) costs, we're increasingly seeing manufacturers move their data to the cloud and shift to an operating expenditure (OPEX) model where they can amortise costs over a longer period of time.

The reasoning behind this is that it is cheaper to rent space in a managed facility rather than buying and maintaining your own servers. Many manufacturers combine this with virtualised and cloud-based systems that can significantly reduce costs but also help smaller businesses scale quickly as they grow.

As well as the way that hardware is managed, the way that data is analysed has also changed. The sheer volume of data now available has made manufacturers realise that collecting more data is only as useful as the specific returns you can extract from it. This has given rise to companies looking for staff dedicated to data analysis.

> **“It is cheaper to rent space in a managed facility rather than buying and maintaining your own servers”**

For example, companies in the automotive sector have for a long time employed quality-analysis personnel dedicated to finding quality improvements, reducing costs and minimising downtime. As we see the nature of analysis change, it is becoming more effective to store data first and then analyse it. This creates the demand for data scientists that can develop algorithms and use machine learning to generate insights. Data engineers can then use this output to improve processes from a practical perspective.

However, we're currently experiencing a shortage of data scientists in the market, something that will decrease as more graduates in these disciplines enter the labour market.

To accelerate this process, we have developed GE Global Research Centers (GRCs). Situated in locations around the world such as the US, India, China, Germany and Brazil, our research centers are home to 2000 PhD-level employees and generate around 3000 patents per year across GE.

They also partner with universities to look for process improvements and develop the latest technology for use by GE; things like artificial intelligence, additive manufacturing, power electronics and the next generation of materials. This relationship is helping us to deliver better projects on a large scale.

> “Our research centers are home to 2000 PhD-level employees and generate around 3000 patents per year across GE”

Much has been said about how Information Technology (IT) and Operational Technology (OT) is converging, with the likes of enterprise resource planning (ERP) and manufacturing requirements planning (MRP) software sharing many overlapping remits, responsibilities and security challenges. What is your experience of this convergence in the automation and controls industry?

Although there is some overlap, for me the two areas have distinct focuses and much of this has to do with immediacy and skills. In a manufacturing business, the IT team might be responsible for working on a slow batch overnight process, producing picking lists, or production lists on a daily or weekly basis.

Conversely, the mission critical nature of operations means that OT staff need to be looking at the process data in real time by the second. If an ERP system goes down, the IT person may be able to make up the work later. If an OT production system in a food and beverage plant fails, it could result in products being scrapped and having to start again.

As organisations begin to integrate many IT and OT systems, it will be important for both IT and OT staff to possess the skills that allow them to seamlessly move from one environment to the other.

> “If an OT production system in a food and beverage plant fails, it could result in products being scrapped”

What specific new jobs do you think will be created, or have already been created in the last ten years, in the automation and controls sector as a result of digitalisation?

We will see three new kinds of jobs: data scientists, staff fluent in both IT and OT and data engineers. A data scientist is someone who analyses the theoretical data and produces a model and digital twin. After this, you need a data engineer. This is someone that takes the scientist's output and puts it into a control system that works in real time. In addition, you also need someone with the relevant IT and OT skills to manage the programming to implement this solution. Currently, OT people lack the database skills and IT people lack the real-time system skills, so merging these skills sets will be vital going forward.

Collaboration is important for innovation. How does GE manage innovation and collaboration across a global organisation?

What we're trying to do is make people aware of what's possible. For example, many of today's plant managers wear two hats, they have to run the plant day to day but also look at how to make it better over time by considering what they're doing now and where they want to be in the future.

At GE, we're trying to get people in these kinds of roles to collaborate across the organisation, allowing them to share their responsibilities and skills. We publish a lot of this research through the GRCs. This collaboration happens through a variety of channels. We have internal marketing and communication activity to keep our staff up to date, we have live-chat systems and forums where people can post common problems that they'd like help with. We also hold symposiums and conferences throughout the year. By building collaboration into the culture, we can ensure everyone from the leadership team to the shop floor staff can realise their ideas and vision.

What new digital technologies have the most potential to revolutionise the automation and controls sector?

While AI, AR and VR are pushing the limits at the high end, for me there is still lots of exciting things going on at the low end. Devices such as the Raspberry Pi have demonstrated just how easy this can be. As the cost of technology comes down, it will be easier to add intelligence to low-level devices. Even basic field components like pushbuttons, limit switches and photoeyes, relays, motor starters and solenoids that make up low-level devices could have their own digital twins that can be interrogated at a very low cost.

Better solid-state memory technology is another area that will continue to evolve. For example, scientists at the University of Alberta in Canada recently perfected a new technique called nanotip technology, manipulating single atoms on a silicon chip, which could lead to storage devices that can hold 1000 times more data. This is the equivalent of storing all 45 million songs on iTunes on the surface of an American quarter dollar coin.

> **“Scientists at the University of Alberta in Canada recently perfected a new technique called nanotip technology”**

Finally, what advice would you give to companies looking to digitalise?

Do it. Depending on what kind of company you are, the first steps are the easiest; get connected using basic sensor technology, begin to generate insights into your processes and then, once you've perfected that, look at how you can optimise your processes. This will help you to monitor your key performance indicators (KPIs) and ask yourself how you can use trends to improve future results.

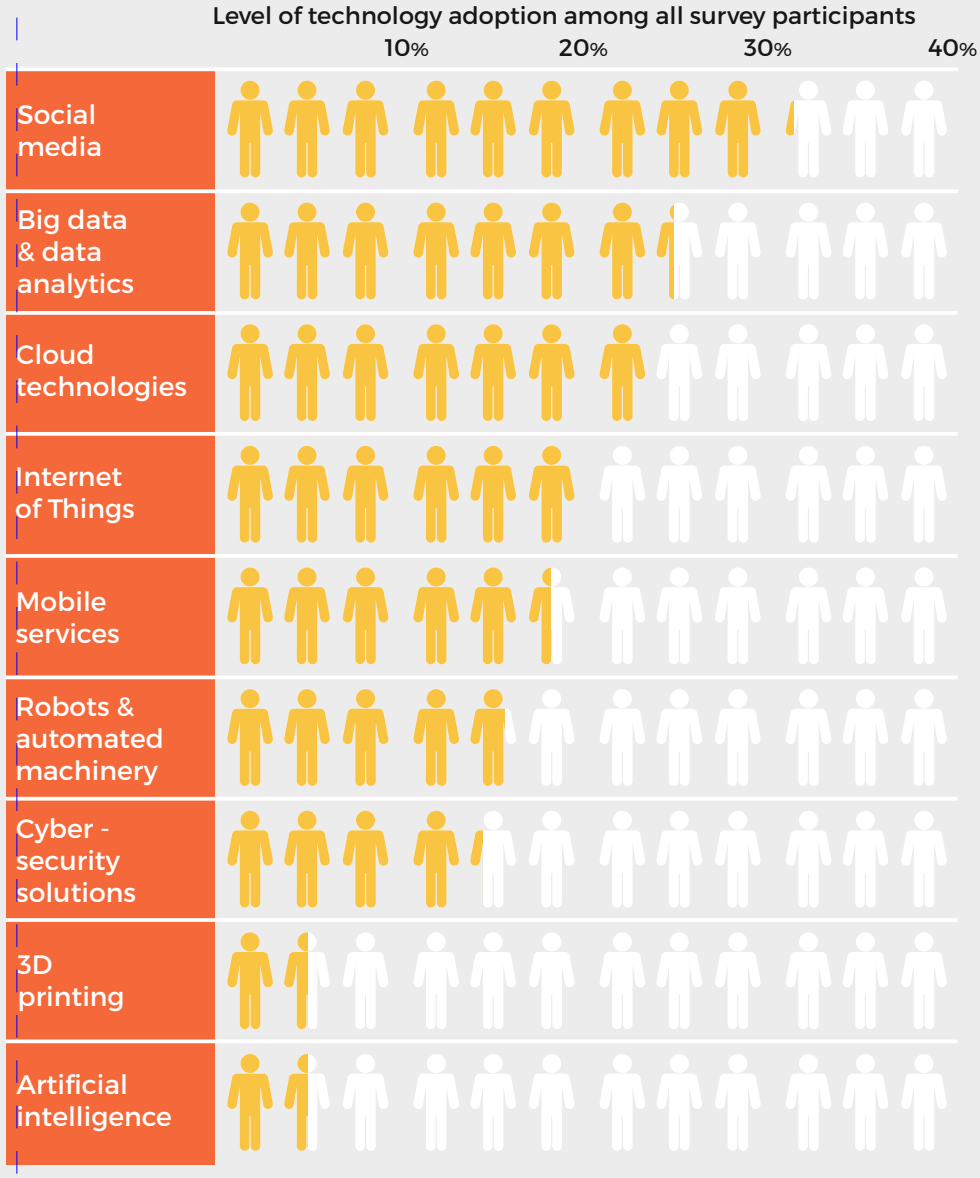
Things change fast in digital industry — you need to adapt to stay ahead of your competitors. A company making widgets today may be tomorrow's software company. It's important that you change your mindset and begin to digitise; otherwise other companies will move ahead.

7

The big nine

Game changing digital technologies

Although most businesses agree that technology will change the industrial sector in the coming years, many have been reluctant to adopt digital technologies. According to the EU Commission's Digital Transformation Survey, fewer than 35 per cent of respondents have adopted at least two of the nine key technologies. Here, we take a look at the big nine and explain how they're changing the game.



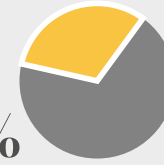
Social media

Traditionally seen as platforms intended to connect friends and families, modern social media is no longer the reserve of pictures of babies and pets. According to a post by Sheryl Sandberg, Facebook's chief operating officer (COO), "There are now more than 50 million small businesses using Facebook Pages to connect with their customers."

Consumers have certainly upped their game. 32 per cent of social media users expect a business to respond within 30 minutes and 42 per cent expect a response within 60 minutes. Likewise, firms that have adopted social media have found it a great platform to engage with customers.

It can also help businesses analyse which products and services do well and how others can be improved and tied in better with marketing and advertising strategies.

In the same way that technology is moving beyond analogue limitations, manufacturers are moving beyond trade shows and print media to promote their latest products. The likes of the LinkedIn publishing platform, sponsored posts, company pages and forums are a great way for industrial businesses to reach their audience.



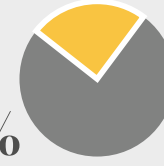
31%

Big data & data analytics

Former executive chairman of Google Eric Schmidt famously said that we now create as much information every two days as we did from the dawn of civilisation to 2003 — around five exabytes a day. With so much data at hand it's understandable that the volume, variety, velocity and veracity of big data can make it difficult to handle.

Generating relevant, high quality data is only the first hurdle. The next is to find insights from the data that the business can act on to get ahead of its competition. As such, companies can now use business intelligence (BI) and computerised maintenance management systems (CMMS) to do much of this legwork.

"We are in the final stages of a shift from IT-led, system-of-record reporting, to business-led, self-service analytics," explained Ian Dowd, chief marketing officer at UK-based SSG Insight. "We recently concluded a major data intelligence project of our customer base and found that work completed on time was shown to improve by over 50 per cent on average as a result of using our CMMS and enterprise asset management (EAM) solutions."



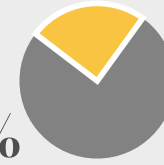
24%

Cloud technologies

Traditional fears around data privacy and cyber security threats mean it has taken years of sluggish adoption for cloud to become mainstream. However, many recent high-profile attacks, often on networks with no internet access, have proven that a company's valuable data is not safe anywhere. Therefore, cloud technologies may provide better redundancy, availability and remote access to teams across global organisations.

Manufacturers are using cloud for everything from Software as a Service (SaaS), online customer relationship management (CRM) systems, data analytics platforms, collaborative working, remote troubleshooting and business continuity planning.

Cloud adoption also varies with company size. According to the DTS survey, ten per cent of companies that have adopted cloud technology have more than 250 employees, with the figure rising to 30 per cent for companies that employ between ten and fifty staff. Despite this, over 88 per cent of all companies surveyed said that adoption of cloud has generated positive outcomes, with some using it to enter new markets and others to gain new customers.

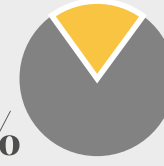


23%

Internet of Things (IoT)

Perhaps the main concept associated with the Fourth Industrial Revolution is the Internet of Things. The IoT consists of physical devices that use embedded electronics, software, sensors and actuators connected to the internet. IoT encompasses home appliances, such as kettles and toasters as well as industrial machines such as pumps and motors. By integrating the physical and digital worlds in this way, the network can exchange data to deliver efficiency improvements, reduce costs and free-up man hours.

Research firm Gartner estimated that there are more than eleven billion connected things used worldwide in 2018. In smart factories, IoT allows engineers to improve traceability, add remote monitoring and predictive maintenance, which alerts the plant manager of an imminent equipment breakdown before it fails. Connectivity also enables the plant manager to transform previously 'dumb' legacy equipment into smart machines that can be tracked in real time from anywhere in the supply chain.



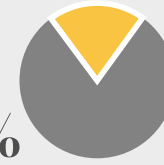
20%

Mobile services

Smartphones, tablets, laptops, smart watches and wearables have become more popular in recent years, making the leap from use in consumer environments to industrial and business applications. The popularity of schemes such as bring-your-own-device (BYOD), combined with better cross-platform interoperability and remote monitoring, means that mobile services offer a powerful and often cheap option for manufacturers to adopt digital technology.

Mobile services also take the form of wireless plant connectivity. Ocado, the world's biggest online grocery retailer developed its own mobile service.

According to The Engineer, "For this project, the partners developed a 4G wireless protocol to control robots in Ocado's new retail warehouse in Andover. It needed to be able to transmit and receive data from thousands of robots concurrently, communicating with each robot ten times per second with guaranteed latency".



18%

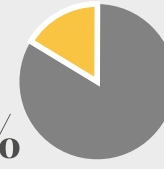
Robots & automated machinery

Robots have been a staple of the automotive manufacturing sector for decades. However, in recent years robotics and automated machines have become a vital part of industries as varied as chemical processing, pharmaceutical manufacturing, and food and beverage production.

Whether it's based on a six-axis, a selective compliance assembly robot arm (SCARA), a cartesian, delta, or collaborative model, today's robots can deliver payloads weighing several tonnes with extreme accuracy and repeatability.

Armed with the latest soft grippers and machine vision technology, robots can work around the clock to pick and pack soft and hard objects like fruit and vegetables while rejecting defective items at very high speeds.

The next generation of automated machinery also includes autonomous guided vehicles (AGVs). These cart-shaped vehicles can navigate factory floors using proximity sensors and vision systems to avoid obstacles and humans, to transport components from one production line to the next.



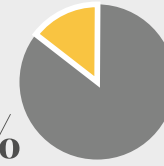
16%

Cybersecurity solutions

Although increased connectivity brings with it a wealth of benefits, many high-profile cyber-attacks have highlighted the disastrous consequences for those that fail to protect themselves. Sophisticated cyberattacks such as WannaCry, Petya and NotPetya have wreaked havoc on utilities, oil and gas and food manufacturing environments in the last five years.

In June 2017, chocolate maker Cadbury had to halt production in its Hobart factory in Australia after its computers were infected with a ransomware virus that encrypted its system data files and demanded payment by cryptocurrency.

Manufacturers can prevent attacks like this or speed up their response time by considering end-to-end digitalisation, better firewall design, intrusion detection and prevention systems, server monitoring and the use of virtual private networks (VPNs).



14%

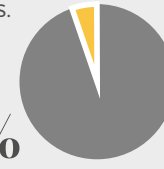
3D printing

Originally pegged as the answer to high tooling costs, long product development times and high-volume production runs, 3D printing has seen slow adoption rates due to high costs and additional finishing requirements.

However, demand for the technology is on the rise. According to research firm MarketsandMarkets, "The 3D printing market is expected to be worth $32.78bn by 2023, at a CAGR of 25.76 per cent between 2017 and 2023. The growth is attributed to factors such as the ease of development of customised products, ability to reduce overall manufacturing costs, and government investments".

3D printing works by adding material layer-by-layer, a direct contrast to subtractive machining where material is removed from a piece of raw material. The technique can be performed in plastic or metal for prototyping and for end-use part manufacture. Also known as additive manufacturing, 3D printing enables the production of metal and plastic parts with complex geometries and lightweight structures.

Because additive manufacturing helps to reduce component weight and has minimal waste, the technology offers particular benefits to the automotive and aerospace industries.



5%

Artificial intelligence (AI)

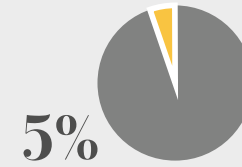
We are very good at assigning human characteristics to inanimate objects, but what happens when the inanimate object can visually perceive its surroundings, recognise speech, translate between languages, and seemingly make high-level cognitive decisions?

AI is intended to do exactly this. By allowing machines to solve problems by 'learning' non-programmed behaviours, we move beyond the realms of simple, automated machine learning, into the world of autonomous, self-regulating systems.

For smart factories this means less downtime, optimised production and better energy management.

There are also benefits to logistics such as seamless information flows with suppliers, self-organised work orders and schedules and better order fulfilment.

Currently, the rate of AI adoption is low. The figures range from four per cent for small firms with less than ten employees, to nine per cent for firms with between ten and 250 employees. However, the popularity and functionality of AI is continuing to improve, and we expect adoption to increase with it.



A Swedish success story

Interview with Tobias Antius, CEO of Novotek AB

Tobias Antius is CEO and managing director of Swedish industrial IT and automation specialist Novotek AB. Starting very young as a programmer in the early 1980s, Antius gained his MSc in Computer Science and Engineering in 1996 and has been delivering industrial IT and automation projects ever since. For the last ten years he has been head of Novotek group, with the aim of positioning the company to support its customers on their digital journey.

“It is my firm belief that we are at a crossroads on the journey to digitalisation, where people and companies have to make a stark choice about their future over the next decade," explains Antius. "In this new era, businesses will either stagnate and die, or embrace and thrive. Novotek's mission is to help its customers stay relevant and prosper.”

> “In this new era, businesses will either stagnate and die, or embrace and thrive”

EU Automation: Can you tell us a little bit about what Novotek does?

Tobias Antius: Novotek came about in 1986 because of the need to integrate technologies such as the PC into industrial applications. At the time, most manufacturers and vendors showed little interest in this area and so the demand for our services has grown ever since.

Over the years, Novotek has done everything from traditional human machine interface (HMI) and supervisory control and data acquisition (SCADA) integration, along with global roll-outs of manufacturing execution systems (MES). Manufacturers have turned to these technologies because they either provide easier inputs, better logging of process data, or improved tracking of products along a manufacturing line.

As a business, Novotek provides the expertise to deliver the right product or architecture to manufacturers. The majority of our business is focused on selling hardware, as opposed to service contracts for ongoing maintenance and repair.

> “Manufacturers have turned to these technologies because they either provide easier inputs, better logging of process data, or improved tracking”

The business is headquartered in Sweden but has operations in other parts of Europe. What led to your growth and export into these markets and what role does the Swedish market play in this in particular?

Yes, Novotek first expanded in the Nordic countries, and then later into Benelux. More recently, it has expanded into the UK and Ireland. Smaller markets like the ones in the Nordic region and Benelux have historically used the latest technologies to stay ahead of their competition, both domestically and internationally, so we also have good demand from these markets.

Although we'd been investigating a possible move to the UK market for quite some time, it was Brexit that provided us with an opportunity to get ahead.

We believe that, together with the wider push towards industrial digitalisation, the UK and Ireland markets will now be spurred to undertake changes to compete on a global scale, and we want to be part of that journey.

Our headquarters in Sweden are important. We are a very Swedish company, with a self-sustaining guiding principle that means we put a lot of faith and trust in our staff to do the job well and make the right decisions.

> "It was Brexit that provided us with an opportunity to get ahead"

Novotek operates in a variety of industry sectors from energy and life sciences, to manufacturing, petrochemicals, food and beverage and water treatment. In your experience, what are some of the key challenges that these industries face from a digitalisation perspective?

I believe it does not matter which industry you're in today, because it will be changed completely in the next five years. Or, to be more precise, if you don't change, you may still exist as a business, but you will not thrive.

The ability to get close to your customers and really help them to become better at assisting their own customers is the key. It's all about establishing partnerships and building a thriving ecosystem. The technology, tools and platforms simply facilitate this end goal. The biggest difference in approach will be in how companies organise themselves and work with each other. By far, the biggest struggle for most people will be adapting to the cultural shift that this brings about.

Sweden's heavy reliance on exports meant that the labour market in the manufacturing sector was affected by the 2008 financial crisis. How did you face this challenge?

Following the previous global financial crisis in the early 1990s, where Sweden's economy took a big hit, the Government implemented economic reforms in the labour market. It also introduced market deregulation and tax reforms to boost foreign direct investment and mitigate the decline in GDP and increased unemployment. As a result, Sweden's business efficiency has improved, and the nation has faced the challenge quite well this time round.

> "The 2008 crisis was not nearly as bad as it could have been, with Sweden recovering more quickly than Denmark, Finland, Iceland and Norway"

These reforms also meant that the 2008 crisis was not nearly as bad as it could have been, with Sweden recovering more quickly than Denmark, Finland, Iceland and Norway.

Though, with that said, since Sweden's exports accounted for 45.3 per cent of GDP in 2017, Novotek's performance is closely linked to our customer's ability to spend. This means that currency fluctuations in international markets that make it more expensive to export can have a detrimental impact. We mitigated this by ensuring that we had a clear strategy, that our supply chain was spread across industries rather than dependent on just a few, so we have been able to avoid shrinking markets in the last five years.

Many low skilled manufacturing jobs will be lost to automation. As a result, there has been a shift of workers to the skilled service sector. What can industry do to upskill existing workers in the industrial sector and choose graduates with the right digital skills?

This is, in many cases, impossible. Although some people can make the journey, in general most industries will have to hire new staff with the right skill set. It's not just low-skilled industrial jobs that will be lost. Automation will also impact mid-level administrative and service jobs in this transition. Many of those jobs were already lost in the Nordic and Benelux regions some years ago, though I know this hasn't happened in the same way in other parts of Europe.

> **“The Swedish school system has witnessed a decline in students' knowledge of mathematics”**

In Sweden, the proportion of people that have recently gained a science or engineering degree is lower than the EU average. Surveys show that in the last decade the Swedish school system has witnessed a decline in students' knowledge of mathematics, reading comprehension and science. Even though the manufacturing industry and related service sector in Sweden employs around a million workers, there is a shortage of people with professional experience in electronics, computer technology and automation.

As part of Sweden's digital transformation of industry, it has developed a strategy called Produktion 2030.

As well as boosting sustainable production, increasing resource efficiency and prioritising environmental considerations, the programme will see the development of an 'industrial skills boost'. Here, the plan is to increase interest in science and engineering subjects, to improve the match between the skills that industry needs and the education system. If we can arm students with the right skills and knowledge and improve the conditions for their lifelong learning, we can promote the sustainable, long-term success of digital industry.

Sweden has been particularly strong at developing the industrial service industry, where businesses sell a complete solution rather than simply focusing on individual products. How do you ensure this in your portfolio?

Because we want to assist our customers in their digital journey, Novotek has been adding new technologies to its stack over the last couple of years. Although this is going slower than expected due to low rates of adoption, we recognise that it's part of a wider cultural shift away from being a product-only company to a complete service provider.

What digital automation technologies have been most popular with your customers and why do you think this is?

Technologies that can be easily integrated into existing systems without reinventing the wheel or overhauling entire plants have been the most popular. Robotics and remote access are by far the most used and most requested technologies over the last two decades.

Sweden wants to move away from fossil fuels and promote the circular economy, which relies on things like reusability and recyclability. How are your customers responding to the need for sustainability and resource efficiency?

Sweden consistently ranks top or highly on many of the global sustainability indexes. The focus for many companies is to reduce their impact on the climate and we continuously help customers with these types of solutions. As companies begin to demand and expect sustainable technologies, it places the onus on their suppliers and customers to do the same. We're also seeing a growing demand for technologies that provide better traceability, so that manufacturers can show the exact journey the product has taken.

> "We're also seeing a growing demand for technologies that provide better traceability, so that manufacturers can show the exact journey the product has taken"

The Government has set a target to improve investment in R&D and improve collaboration between academia and industry. What do we need to do to innovate, and what role is Novotek taking in this?

For Novotek, innovation has always been a core value and we have always worked closely with academia to some degree, interacting heavily with researchers. Innovation is all about jumping in, taking the leap of faith and daring to lose in order to win. The biggest obstacle to innovation is changing the culture in industrial organisations, where people can be reluctant to change, to one that is more disruptive by nature.

Although many larger companies have the resources to digitalise effectively, smaller companies may struggle to keep pace. What would be your advice for those looking to digitalise?

Dare to think big! Start with small wins for you and your customers and then grow from there. I'm a fan of The Lean Start-up philosophy, which focuses on asking the question 'what does my customer need?' and then works backwards from that, using technology in the process. Another piece of advice is that you shouldn't assume you have the skills already — talk to experts and consultants before you start.

A summary of Smart Industry in Sweden

- Sweden's digital initiative is called Smart Industry and focuses on four things: transforming industry, sustainable production, boosting skills, and improving research collaboration.
- The industrial sector in Sweden is responsible for a fifth of the country's GDP, accounting for 77 per cent of the total value of Swedish exports.
- The Swedish Government has set a goal of becoming one of the world's first fossil-free welfare states. Using fewer resources and reducing emissions is one way to do this.
- Sweden has developed a strategy called Produktion 2030. In part, the programme will see the development of an 'industrial skills boost' to increase interest in science and engineering subjects, to improve the match between the skills that industry needs and the education system.

9

Going from a crisis to a competition

How the US turned around its manufacturing sector

Even though the US economy is the largest in the world by nominal GDP, it was a crisis in the manufacturing sector that prompted the US Government to act to save the industrial sector over the last decade.

On the face of it, the US manufacturing sector accounts for 11.6 per cent of GDP, employs over 12m people and makes up two thirds of all exports. Look below the surface, however, and the economy hasn't always been as healthy. From about 1980 to 1985, and then again from 2001 to 2009, the US experienced a greater decline in manufacturing jobs even than that experienced during the Great Depression. According to the Information Technology & Innovation Foundation in the US, it is estimated that between a third of all manufacturing jobs were lost between 2001 - 2009.

> **“Between a third of all manufacturing jobs were lost between 2001 - 2009”**

The manufacturing crisis has been attributed to a variety of causes, from an annual trade deficit, a reliance on outsourcing and the growth of domestic industries such as finance, construction, real estate and services. However, probably the biggest reason for many is China's meteoric rise following its entry into the World Trade Organisation (WTO) in 2001, which MIT economists have directly attributed to the loss of 560,000 American jobs.

As a result, the last two decades have seen the US Government tackle this problem with a range of policy changes and international agreements that have sought to build on the US' strongest international trading partners.

In 1994, the US signed the North American Free Trade Agreement (NAFTA), which is a trilateral agreement between the US and it's two biggest export partners Canada and Mexico. The goal of the agreement was to eliminate trade barriers between the three countries by promoting tariff-free trade.

Over two decades on, and most agree that NAFTA has been a success. While Canada arguably benefited the least, it still improved productivity, which rose 15 per cent in 2008 alone, reduced unemployment and increased agricultural flows.

All three countries gained increased trade volumes, with Mexico benefiting the most. Mexico's GDP per capita increased by 40 per cent and, according to a report in the Washington Times, "About 47 percent of Mexico's 115 million people live in poverty, down dramatically from the 80 percent rate half a century ago. Today, 98 percent of homes have electricity, and more than four million people study at the university level each year.”

> **“Mexico now produces more engineering graduates than Germany”**

An improvement in basic living conditions, combined with a growing middle class — in addition to the creation of around 120 new engineering universities — led to an increase in engineering graduates. In fact, Mexico now produces more engineering graduates than Germany. Graduates in Mexico with an engineering, manufacturing or construction degree totalled 113,944 in 2015, compared to Germany's 93,329 according to the World Economic Forum's Global Human Capital report.

Manufacturing USA

Having stemmed the loss of manufacturing jobs, the US has more recently engaged in a programme to better position the industry to face the challenge of advanced manufacturing in the 21st Century.

On January 15, 2014, president Obama gave a speech at North Carolina State University, where he set out his vision of a new phase of manufacturing innovation. In it, he talked about Manufacturing USA, the brand name for a policy initiative called the National Network for Manufacturing Innovation (NNMI).

Modelled after the Fraunhofer institutes of Germany, the NNMI is a network of 14 research institutes designed to foster the improved design, development and commercialisation of innovative new manufacturing technologies. The stated purpose of the network is, "to increase US manufacturing competitiveness and promote a robust and sustainable national manufacturing R&D infrastructure".

The NNMI is made up of public and private companies, universities, government agencies and non-profit organisations. The institutes are located in regions around the US making the best use of the local skills and resources available and concentrating research in a specific area.

The institutes range in specialisms, covering areas including: additive manufacturing, robotics, design engineering, smart manufacturing, lightweight and advanced materials and composites, power electronics, photonics, flexible electronics, cell regeneration, clean energy and biopharmaceuticals.

The Manufacturing USA programme is administered by the interagency Advanced Manufacturing National Program Office (AMNPO), which works in partnership with the Department of Defense, the Department of Energy, NASA, the National Science Foundation and the Departments of Education, Agriculture, Health and Human Services (HHS) and Labor.

Manufacturing USA
The list of Institutes

America Makes - The National Additive Manufacturing Innovation Institute (NAMII)
The Digital Manufacturing and Design Innovation Institute (DMDII)
The Clean Energy Smart Manufacturing Innovation Institute (CESMII)
The Institute for Advanced Composites Manufacturing Innovation (IACMI)
Lightweight Innovations for Tomorrow (LIFT)
Power America, for next-generation power electronics
The American Institute for Manufacturing Integrated Photonics (AIM Photonics)
NextFlex, for flexible hybrid electronics
Advanced Functional Fabrics of America (AFFOA)
The Rapid Advancement in Process Intensification Deployment Institute (RAPID)
BioFabUSA - The Advanced Regenerative Manufacturing Institute (ARMI)
The Institute for Reducing Embodied-energy And Decreasing Emissions in Materials Manufacturing (REMADE)
The Advanced Robotics Manufacturing (ARM) Institute
The National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL)

Some of the institutions have a greater focus on digital technologies than the others. These include:

ARM
The Advanced Robotics Manufacturing (ARM) Institute was established to, "develop, demonstrate and accelerate the early adoption of novel robotic solutions." Its four overarching goals are focused on empowering American workers to compete with low-wage workers abroad; helping the creation of new jobs to secure US national prosperity; lowering the technical, operational and economic barriers to adopt robotic technologies; and asserting US leadership in advanced robotics for manufacturing.

> "Gripper technology is another challenge the institute wants to improve, to allow robots to become more dextrous"

To achieve these goals, the institute has identified seven 'technology thrust areas' which include: human-robot interaction; scheduling, learning and control; dextrous manipulation; mobility and navigation; perception and sensing; testing, verification and validation; and mechanism design.

These areas are solving specific challenges such as helping a robot to automatically identify objects so that it can quickly pack and unpack them as well as being able to navigate complex factories with crowded floor spaces. Gripper technology is another challenge the institute wants to improve, to allow robots to become more dextrous and better able to handle items such as soft fruits and vegetables in a grocery warehouse, for example.

The Digital Manufacturing and Design Innovation Institute (DMDII)
The DMDII is the hub for digital manufacturing and design innovation. In a promotional video outlining the institution's work, Caralynn Nowinski Collens, managing director of the DMDII says, "We're the place where companies of all sizes meet up with innovators to plot the future of manufacturing. This is where you take things like data and artificial intelligence and the Internet of Things and piece it all together to figure out how we can advance an entire industry."

> "The DMDII has delivered, or is currently working on, around 60 projects"

To achieve this, the institution has four 'technology thrust areas'. The first is called Design, Product Development and Systems Engineering; the second is called the Future Factory; the third looks at creating agile, resilient supply chains; and all of this is underpinned by a focus on cybersecurity in manufacturing.

The DMDII has delivered, or is currently working on, around 60 projects across these thrust areas — awarding approximately $95m dollars in funding to projects involving some 163 organisations. Of the projects it has already awarded, one looks at the use of composite materials to create better wind turbine blades. Another looks at developing a computational tool to automatically transform a computer-aided design (CAD) model into a virtual assembly process with almost no input from the user.

It's a similar story for the other projects, most of which are in some way helping to reduce costs, improve efficiency, help people complete tasks quicker or work more flexibly from remote locations, using their own tablets and mobile devices.

Highlights of Manufacturing USA
An independent assessment of Manufacturing USA by professional services firm Deloitte found that the first eight institutes, established between 2012 and 2016 have, "reached a critical mass of valuable connections among participating companies, universities, and other entities. Those connections are accelerating the innovations needed to develop new products and markets, helping alleviate a shortage of technically trained manufacturing workers and building a sustainable national manufacturing research infrastructure."

Although only nine of the fourteen institutes are currently active, the programme is making quick progress. The network now has 830 industry members, two-thirds (548) of which are manufacturing firms, including 361 small businesses. Non-federal funding received by the network has exceeded the original goal of one-to-one matched funding, with federal funding being matched at a two-to-one ratio.

The network has delivered, or is working on delivering, around 200 major applied research projects, which have reached out to 28,000 people including students from twelfth grade to university, as well as manufacturing employees and veterans.

> "Those connections are accelerating the innovations needed to develop new products and markets"

Challenges
Despite the successes, the US still has challenges ahead in the journey to digitalisation and initiatives such as Manufacturing USA are going a long way towards solving these. The network needs to become more market driven, rather than agency driven — working to achieve better integration so that it can solve the broader technological problems the country faces, rather than single issues. Although the US is good at delivering research and development, it has historically struggled to convert this into business success, so putting the onus on the commercialisation of innovation will help to achieve this.

> "The network needs to become more market driven, rather than agency driven"

President Obama's speech

North Carolina State University – January 15, 2014 (edited for brevity)

“Now, it's been more than five years since a devastating recession cost this country millions of jobs... but everyone here knows that even before the recession hit, the middle class had been getting hit on the chin for years before that... factories were shutting their doors, jobs were getting shipped overseas. Wages and incomes were flat-lining...

"So, when I took office, we decided to focus on the hard work of rebuilding our economy... for decades we'd been losing manufacturing jobs. But now our manufacturers have added over the last four years more than 550,000 new jobs, including almost 80,000 manufacturing jobs in the last five months alone. So, we want to keep that trend going...

"So, a little over a year ago, we launched America's first manufacturing innovation institute in Youngstown, Ohio... now, that was a great start... but here's the problem: We created one; in Germany, they've already got about 60 of these manufacturing innovation hubs. So, we've got some catching up to do. I don't want the next big job-creating discovery, the research and technology to be in Germany or China or Japan. I want it to be right here in the United States of America. I want it to be right here in North Carolina.

"In my State of the Union address last year, I said to Congress, let's set up a network of at least 15 of these manufacturing hubs all across America. So today, after almost a year of competition, I'm pleased to announce America's newest high-tech manufacturing hub... The Next Generation Power Electronics Innovation Institute is bringing together leading companies, universities, and federal research all together under one roof. Folks at this hub are going to develop what are called 'wide bandgap semiconductors'.

"Now, I was just schooled on all this. (Laughter.) I'm not sure that I'm fully qualified to describe the technical elements of this. Raise your hand if you know what that is. (Laughter.) See, we've got some. (Laughter.) For all you non-engineers out there, here's what it means in the simplest terms. Semiconductors, obviously, are at the heart of every piece of the electronics that we use every day — your smartphone, your television set, these days, everything...

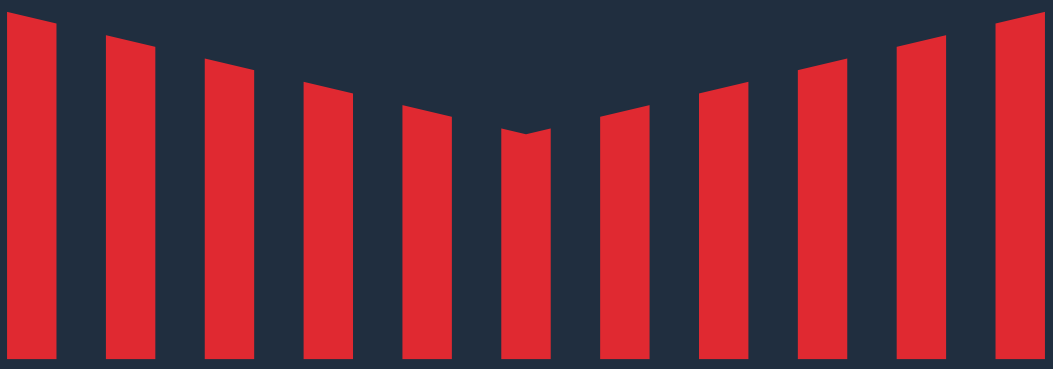
“Wide bandgap semiconductors, they're special because they lose up to 90 percent less power; they can operate at higher temperatures than normal semiconductors. So that means they can make everything from cell phones to industrial motors to electric cars smaller, faster, cheaper...

"So, this manufacturing hub... is going to make it easier for these wide bandgap semiconductors to go from the drawing board to the factory floor to the store shelves... [it's going to help] utility companies or help windmills translate the power they're generating actually get transmitted to where [it is] going to be finally used.

"It's going to bring together chip designers and manufacturers with companies like Vacon and Delphi that stand to benefit from these new technologies. And this will help big companies, but it's also going to help small companies, because they're going to be able to use equipment they otherwise wouldn't be able to afford to test and prototype new products...

"And that's what America is all about. We have always been about research, innovation, and then commercializing that research and innovation so that everybody can benefit. And then we start selling our stuff all around the world, we start exporting it...

"Now, this is going to be a long haul. We're not going to turn things around overnight. A lot of jobs were lost in the textile industry and furniture-making. But the great news is, is that ultimately, because our people are good and smart and hardworking and willing to take risks, we are going to be able to start bringing those jobs back to America. And that's what we do. (Applause.) When times get tough, we don't give up. We get up. We innovate. We adapt. We keep going. We look to the future. (Applause.)



My taste buds are tingling

Interview with Todd Gilliam, US food and beverage segment leader for ABB

Todd Gilliam is US food and beverage segment leader for ABB. He leads the sales and support efforts for the food and beverage industry, working with end user manufacturers, original equipment manufacturers, systems integrators, consultants and panel builders among others. Gilliam is a degree-educated electrical and computer engineer and has spent his career of 31 years in the technical sales field working for companies such as Schneider Electric, Microsoft, Rockwell Automation and Oracle.

ABB is a technology leader in electrification products, robotics and motion, industrial automation and power grids, serving customers in utilities and industry, as well as transport and infrastructure globally. ABB operates in more than 100 countries with about 147,000 employees and reported a revenue of $34.3bn in 2017.

EU Automation: The changing nature of consumer behaviour has given rise to trends such as 'field-to-fork' traceability and even mass personalisation. In your experience, how has the food and beverage market changed over the last few years?

Todd Gilliam: It's more dynamic than it's ever been, and manufacturing customisation and personalisation is reflective of that. For example, when I was at Microsoft as a global account manager for Coca-Cola, the company launched its 'Share-a-Coke' campaign. This involved printing a different personal name for each can or bottle, making mass personalisation a reality.

Projects like this have driven changes in consumer expectations over the last few years. The need to produce unique flavour extensions in brands including Diet Coke or Coke Zero — such as Cherry, Vanilla, or Ginger Lime — means that manufacturers have to rapidly respond to market conditions. They must also meet demand for bottles and cans made of plastic, glass or metal. Businesses can no longer produce the same product, in a single flavour and in the same type of packaging 24/7 365 days a year.

It's also important to consider seasonal demand. Events like Independence Day, Memorial Day, Halloween, The Super Bowl and World Series in the USA all force manufacturers to customise and alter their production lines in preparation. Sometimes, this even extends to local events. For example, consumers may want their local sports team's logos on products.

Personalisation aside, consumers also want to know the basics of what's in their product. They want clean and easy to understand labelling and they want to know if it was produced in accordance with environmental standards, or whether the ingredients were sourced from local farms. In recent years, we've also seen customers begin to ask, "will this make me ill?" in relation to allergies such as gluten and nuts. Today's consumers are much more aware in this regard and it can be challenging for many manufacturers to change production setups to keep pace with the progress made by marketing and sales teams. This is where Industry 4.0 comes in.

More manufacturers are now using automation, however, unlike sectors such as automotive, the perishable nature of foods and the variability of handling hard and soft produce of different sizes poses a unique challenge. What are the different challenges the food industry faces?

The first big challenge is food safety. In manufacturing environments that handle meat, poultry, dairy and juice, it's important to have stainless steel equipment such as motors that can be washed down after each shift. This means they need to be rated to standards like IP69K where they may have to withstand high pressure jets of water at high temperatures using detergents and caustic, corrosive cleaners.

Our food and beverage customers want equipment and connections that are anti-microbial and food-safe to greatly reduce liquid ingress. Robots also, for example, have very different requirements depending on whether they're being used in automotive or food environments.

> “food and beverage customers want equipment and connections that are anti-microbial and food-safe to greatly reduce liquid ingress”

Another big challenge, this time for robotic arms, is gripping irregular shaped items. A discrete widget manufacturer typically knows the exact variables of the item they are producing. Compare that to a food manufacturer that might be simultaneously processing chicken nuggets or packaging a cut of meat, the variables are much more unpredictable. A lot more engineering thought needs to go into this.

The engineering design team must also consider food environments that are often wet and dirty, that need to be constantly cleaned or washed down. For example, in the brewing industry, clean-in-place (CIP) standards are mandatory for equipment that cannot be changed or moved, as different products are produced in succession.

Robotics makes up a big part of ABB's global business. What advancements in robotics have specifically helped the food and beverage market?

Robots in food and beverage have traditionally been used for tasks such as pick-and-place and end-of-line picking, packing and palletising applications. Additionally, they've been used for tray packing, dispensing, capping and shrink wrapping. Typically, these robots have operated from behind safeguards such as cages and light curtains, so they can maintain speed and accuracy, while preventing operators from being injured by moving parts, or a swinging arm.

Now, we're seeing a lot of interest from our customers asking for collaborative robots such as ABB's YuMi, a desktop robot that operates safely next to humans and can work independently or in coordination with a person. This means it can be used as a working partner to complement the workforce, rather than replace them.

We've also used wireless technologies to allow us to operate equipment in smaller spaces, so they don't take up as much room and so they're safer to use alongside humans. ABB's acquisition of industrial automation specialist B&R has also been a great addition for our food and beverage industry segment team. B&R is a leader in automation and multi-axis servo control and precise motion control, which will be vital in developing a standardised platform that can be tailored to each application.

What other digital technologies are having an impact on the food and beverage market?

ABB has developed smart sensors that can be attached to the frame of a traditional motor, and wirelessly uses Bluetooth Low Energy to send data to smartphones and PCs. It can even encrypt the data and send it to the cloud for further analysis. It can measure variables such as vibration, motor health, cooling efficiency, temperature and how much energy the motor is consuming.

This means that plant or maintenance managers can easily see when something is wrong, when a motor is about to fail and when it needs attention for repairs or maintenance. Many companies have popularised the notion of AI based predictive maintenance and I'm often asked by customers where they can start with digitalisation. One of the best places to start is condition-based monitoring. You can easily see when the product is vibrating too much, or if it's getting too hot and this data is easily incorporated into a monitoring system.

> "the data can be analysed remotely by anyone with the relevant permissions in the business or supply chain"

Even a few years ago, there was some reluctance to move manufacturing data to the cloud. However, with the proliferation of secure cloud platforms such as Microsoft Azure, Amazon Web Services (AWS) and others, this mindset is rapidly changing with our manufacturing customers.

As a plant manager, you may have been using plant-based historian databases, which would be connected to a local server on the site. This could be collecting process data on very frequent and regular intervals, all day long, for many years. If and when the local hard drive or server eventually failed, or lost network connection, you might lose years of data and eventually have to replace it anyway. Your only alternative may have been to engage, hire or outsource an IT team to maintain it. However, they would likely have to be based in the plant, or visit regularly, since the data would not be remotely accessible.

> "One of the best places to start is condition-based monitoring"

This data may now be stored in a private, public or hybrid cloud located in a managed data centre. Here, the data can be analysed remotely by anyone with the relevant permissions in the business or supply chain, making it easier to manage SCADA systems and supplier networks. This technological shift has certainly changed the game and means that manufacturing and engineering teams don't also need to act as IT teams.

Another area of industry that has been changed by technology is energy efficiency. Wireless technologies are giving manufacturers a better ability to drastically reduce their measurement, and ultimately consumption, of resources including water, air, gas, electricity and steam (WAGES). By using internet-connected temperature and flow meters and digital sensors, manufacturers can measure areas of high consumption that can then be optimised and improved.

Combine this with Ethernet plant-floor networks, and it is possible to reduce energy use significantly. These headline savings are also likely to convince business leaders that investing in such technology is worthwhile. This is especially useful for small plants that can achieve much lower project costs. Pilot projects that may have previously lasted a year and potentially cost millions of dollars, can run for three months and cost a fraction of what they did previously.

> “Retraining and finding skilled workers can be difficult and STEM jobs are becoming harder to fill and replace”

Automation will also impact jobs in the food and beverage market, especially low skilled jobs such as end-of-line picking and packing. Despite some jobs losses, we also know that automation will have an overall net positive impact on creating new jobs. How can industry manage the need to upskill and retrain existing workers?

Workforce readiness is a concern for many of our customers. Retraining and finding skilled workers can be difficult and STEM jobs are becoming harder to fill and replace. The newer generation of technical graduates may not want to work in a plant environment. They increasingly migrate toward more commercial technical jobs or companies (Amazon, Twitter, Facebook, Apple, Microsoft, etc.), where they are attracted to the latest cutting-edge technology. Similarly, if they don't see the latest digital technology on the manufacturing shop floor, they are unlikely to want to work in our more conservative industry. Familiar interfaces, devices and things like multitouch technology can make all the difference.

We talk to our customers about keeping up with the latest developments in technology to be a more attractive employer. Manufacturers are often reluctant to make changes that don't result in quantifiable returns in the short term. Part of our job is to explain that while it's important to keep up with product output, if you don't have the right employees, you may not be able to make the products in a few years' time.

When designing plants of the future, it's important that manufacturers think about collaborative areas and worker-friendly environments that are conducive to staff learning. Today's workers will only buy into the business vision if they can see how they will be developed personally and professionally and how they can make progress with the right financial incentives. This is why industrial businesses will need to replicate many of the constructs that have been successful in commercial settings.

> “if you don't have the right employees, you may not be able to make the products in a few years' time”

Food recalls and contamination incidents are on the rise. How is ABB helping food manufacturers overcome this challenge?

We have created an entire philosophy around designing and enabling food-safe equipment. If we can reduce the opportunities for bacteria to hide and reside, they are less likely to proliferate in wet and moist environments. By eliminating crevices and making equipment with smooth and seamless edges — and choosing materials such as stainless steel — we can ensure that it can be more easily washed and wiped down.

ABB's acquisition of wire and cable-management leader Thomas & Betts has enhanced our portfolio of conduit systems, connectors, cables and fittings that can be washed down. This is especially useful in high risk areas such as meat, poultry and dairy. We typically provide customers with a site assessment that highlights Food and Drug Administration (FDA), Food Safety Modernization Act (FSMA) and National Sanitation Foundation (NSF) violations and other concerns we have.

We also give thought to things that most manufacturers would overlook. Even something as simple as a label or a sticker has edges, so we now etch that information directly into the surface of the material. By building these practises into the DNA of design engineers' work, we can help minimise and prevent food safety concerns and product recalls.

> "I often say to customers, that the first thing they must do is define why they want to digitalise"

What would be your advice for manufacturers looking to digitalise?

I often say to customers, that the first thing they must do is define why they want to digitalise. Are they doing it because of a corporate edict from their chief technology officer (CTO) or chief information security officer (CISO), to generally keep up with industry trends, or to genuinely reap the competitive advantage and benefits that technology can deliver in the long term?

My advice would be to start with something achievable; don't try and boil the ocean. Use something simple like smart sensors to begin collecting data and start monitoring processes. Other times, it may be as simple as providing suppliers, such as OEM equipment partners, with remote access into the corporate network to troubleshoot their equipment. This might mean they don't have to fly a technician in from Germany or Italy, or wherever in the world the vendor is based, to complete a simple five-minute fix. Once customers are familiar with the basics, that's when you can start experimenting with more sophisticated analytics and optimisations to realise the most savings.

> "Most manufacturers now have products fitted with IP-ready functionality so going digital is not difficult"

Another piece of advice is that when procuring new capital projects, buy digital-ready parts and machinery. Most manufacturers now have products fitted with IP-ready functionality so going digital is not difficult. Because industrial equipment may have a twenty-year or longer product life-cycle, buying equipment that is future-proofed is a good investment justification. To summarise, ask yourself why you are going digital, then start with something workable, and then design in the capability for the future.

Going beyond industry with Society 5.0

Interview with Nigel Smith
CEO of TM Robotics

Nigel Smith is CEO of TM Robotics, the exclusive distributor of Toshiba Machine for Europe, the Middle East and Africa (EMEA), as well as North and South America. Smith has worked for Toshiba for 32 years and has specialised in PLC and industrial automation products since 1986. Following Toshiba Corporation's restructure, TM Robotics (Europe) Ltd. was setup to provide marketing, sales and support for robotics in EMEA.

The history of Toshiba Machine Co. Ltd. goes back to 1938 and the company is based in Numazu City, Shizuoka, Japan. It reported consolidated annual sales of ¥116,862 million in 2017 and employs over 3,200 people.

As an engineering company based in Japan, Toshiba Machine is part of the national movement to use technology to enhance society beyond the scope of the factory floor. This vision, in the form of Society 5.0, may prompt companies around the world to reconsider the way they innovate and our relationship with technology in the future.

> “Society 5.0, may prompt companies around the world to reconsider the way they innovate”

EU Automation: Can you tell us a little about Toshiba Machine Co. Ltd. and what the company does?

Nigel Smith: The history of the company goes back to 1875 when The Shibaura Engineering Works Co. was established. In 1938, this became the Shibaura Machine Tool Co. which led to the founding of Toshiba Machine in 1961.

Today, Toshiba Machine operates with four core technology divisions: machine tools, plastic injection moulding, die casting and control systems. Although the machine tool market led demand when the business was first established, now, around half of the company's turnover can be attributed to plastic injection moulding technology, of which Toshiba Machine is a market leader.

Another large part of the business, which is seeing rapidly growing demand from around the world, is the control systems division. It manufactures and sells PLCs, servo motors, industrial robots and numerical controllers.

> “Robots have dominated automotive applications for a long time”

Robots are increasingly being used in a wide variety of sectors. How have your customers' requirements changed in the last few years and what challenges remain?

Whether it's spot or arc welding or painting, robots have dominated automotive applications for a long time. In the last few years, however, we've seen robots being used in increasingly varied sectors from food and pharmaceutical to medical and plastics manufacturing.

Customers have been better served by more reliable robots. Where hydraulics may have been used previously, the shift to electrical actuation has drastically improved reliability and accuracy. This has also popularised the use of remote monitoring to gain insights into mechanical or control issues and plant managers can now carry out preventative maintenance before an issue stops production.

Another challenge that has been solved in the last few years is interfacing. Connecting a robot to peripheral devices required a dedicated control interface for proprietary fieldbus protocols such as Profibus, EtherNet/IP and DeviceNet. If you're a plant manager and you want to connect a peripheral device such as a vision system to a robot, you can now do so easily. This is useful for end-of-line packaging, conveyor tracking, quality inspection and even for things like 3D bin-picking and sorting for order fulfilment.

A challenge that continues to affect many businesses is choosing the right robot. Because robots are becoming easier to use and maintain, cheaper, more efficient and easily deployable, there is a wider variety of options to choose from. This makes it even more important that engineers choose one with the right blend of features to match the needs of the application. Although a desktop collaborative robot might be tempting because it's popular right now, you must think carefully about whether a six-axis, SCARA, cartesian, or delta robot will not be more effective, and cheaper, for a given application.

> “A challenge that continues to affect many businesses is choosing the right robot”

According to the International Federation of Robotics (IFR), Japan is the world's predominant industrial robot manufacturer. How are you responding to growing sales of robots in China (and to a lesser extent in Korea, USA and Germany)?

China is one of the core markets for Toshiba Machine, which is why it recently opened a manufacturing facility in China, within the already existing Toshiba Machine Shanghai Co. factory. This facility predominantly manufactures SCARA robots for the growing electronics assembly market in China. By having a local presence, we can meet production demand and provide faster deliveries.

However, this high-volume demand is creating an industry-wide shortage of many second and third-tier components used in robots. Parts such as Harmonic Drives, RV gears and ball screws are responsible for delivering the lightweight and high accuracy articulation and motion that we've come to expect of robots. While alternatives to these components exist from local suppliers in China, manufacturers value the high quality, precision and reliability of Japanese and German parts. As suppliers work to reduce lead-times, we will see supply catch-up with demand.

> “This high-volume demand is creating an industry - wide shortage of many second and third-tier components used in robots”

According to Japan's Business Federation (Keidanren) - Society 5.0 is the era of the super-smart society. It goes beyond the automation and information age and aims to build solutions for better human life. What does Society 5.0 mean to you?

To date, many digital transformation programmes have been limited to certain areas of the economy such as industry, healthcare or retail. Society 5.0 is the first programme that goes beyond industrial automation and aims to use some of the same technologies to improve people's lives.

Japan has the oldest population in the world, with over a quarter of people aged 65 or over. It also has a shrinking workforce and low productivity, issues that are ultimately affecting the country's GDP. It is essential that many of the technologies used in automation should be developed for wider use. For example, things like remote monitoring and cloud access could help GPs monitor the health of patients with chronic conditions by using wearable devices. Service robots and autonomous guided vehicles could help to move heavy cages and trollies around hospitals.

> “Japan has the oldest population in the world, with over a quarter of people aged 65 or over”

Japan is famous for 'monozukuri' or 'excellence in manufacturing'. This has traditionally been possible because of the wide availability of real-time data and adoption of the latest technologies. What new automation technologies will ensure that Japan continues to lead innovation?

Being able to communicate process data in real time using remote condition monitoring is very useful. A factory in China can send data back to head office in Tokyo so that engineers can make more informed and timely decisions. Engineers can monitor the efficiency of machinery and ensure that it continues to operate at the right level.

Technology like this also has an impact on customer service. Our customers — and their customers in turn — depend on being able to respond quickly, to stay ahead of the competition. To facilitate this, we need to use technologies that allow us to offer better technical support, better responses to issues in the factory and better-quality output.

As well as making people's lives more comfortable, how will Society 5.0 solve some of the wider environmental issues such as renewable energy and resource efficiency? What is Toshiba Machine doing in this respect?

Toshiba Machine Japan is committed to making people's lives easier. Our corporate principles are made up of three areas: a commitment to people, a commitment to the future and a commitment to society. As well as serving our customers and shareholders, we make sure that we innovate in a way that considers the environmental impact of our products.

For example, we've developed two robot ranges, the TVL six-axis and THL SCARA range, which are lighter and more energy efficient than previous models. The THL range, for example, offers a weight and energy saving of up to 50 per cent compared to older SCARA models.

Our robotic systems have also been used in specialised applications. One of our customers has used our technology to develop specialised painting and coating robots for use in the consumer electronics sector. By using our robots, they have been able to reduce their paint usage by 60 to 70 per cent. This not only drastically reduces the cost of paint spraying, it also reduces the environmental impact of waste paint.

> I would suggest that companies embrace new interfaces that allow them to add peripheral devices

What advice do you have for companies in Japan looking to digitalise their manufacturing?

Japan has a strong tradition of engineering, with lots of specialised companies that aren't prone to making compromises in quality. These companies don't take technological adoption lightly and only consider technologies that will bring about a markedly long-term improvement in their offering. For this environment, I would suggest that companies embrace new interfaces that allow them to add peripheral devices without overhauling existing equipment and use it to optimise repetitive tasks, then take it from there.

What is... Society 5.0?

Society 1.0 dates back to when humans were hunter-gatherers. Society 2.0 was the agrarian society and Society 3.0 was the industrial society, comparable to the First Industrial Revolution in the western model that used mechanisation and steam power. Society 4.0 was the information society, comparable to the digital revolution and Society 5.0 is comparable to Industry 4.0 but with one key difference. It hopes to solve some of the larger societal problems faced particularly in Japan. These problems include an ageing population — the oldest in the world — and low economic productivity.

12

The rise of China

How this cradle of civilisation is rising once again

China was a prosperous nation many centuries, indeed many thousands of years, before western civilisation rose to prominence and long before its growth made it the darling of the financial sector. However, China's industrialisation over the course of the twentieth century — becoming one of the world's major cheap manufacturing nations — has saddled the country with a bad image.

For decades, China has been associated with poor quality products, a culture of counterfeiting and an economic philosophy that can be summarised by the saying, "stack 'em high and sell 'em cheap." However, this wasn't always the case.

According to analysis by Business Insider, "In the 15th and 16th centuries, China accounted for 25 to 30 per cent of the global economy, but by the 1950s and 1960s, after the destruction of World War II and under the rule of Mao Zedong, it fell below five per cent." Today, China makes up about 18 per cent of the global economy — the US accounts for around 15 per cent.

In its golden age, China was famous for trading routes such as the Silk Road, which connected the East and West. Its routes spanned land and sea and joined Asia with the Middle East and Europe. As well as the lucrative trade in silk and other precious textiles and spices, the Silk Road was responsible for the dissemination of religion, politics and technology. Inventions that originated in China include the pulp papermaking process, movable type printing, gunpowder and the compass.

> **“Inventions that originated in China include the pulp papermaking process, movable type printing, gunpowder and the compass”**

According to economic historian Joel Mokyr, "China was extremely innovative in its heyday, which is basically under the Song dynasty, which ended in 1279. At that time, European and Islamic travellers realised that China was leading the world in technology. And China does have kind of an Enlightenment. And yet, in the end, they did not turn that innovation into sustained economic growth. I believe the fundamental reason is China's position as a single empire, and also its bureaucracy.

“China has a glorious past in its scientific achievements. And yet they were never able to turn it into economic growth as the West did. If you look at Europe and China in the 19th century, Europe is advancing at breath taking speed. It's building a rail network, steamships, factories. By the early 20th century, China looked like it was going to be completely occupied by imperialist powers."

Part of the reason why Europe was successful was that there was no one, single force unifying it. Warring factions, trade disputes and frequent power struggles served to increase competitiveness and, therefore, innovation. Compare that to the relatively stable dynastic and imperial rule experienced in China for thousands of years, it's clear why China didn't experience any industrial revolutions.

> Part of the reason why Europe was successful was that there was no one, single force unifying it

New China

Today, the Chinese economy is still heavily restricted by Government interventions. However, since the 1970s China has made a concerted effort to reform its economy, going from a closed, centralised system to a market-oriented one. Its move from a low-cost economy to a value added one has seen a shift away from agriculture to industry. This founding of new China has seen the Government relax prices, introduce fiscal policies to promote enterprise growth in the private sector and help the stock market and banking system compete on a global scale.

The results of these changes over the last four decades have been astounding. According to the World Factbook, "Measured on a purchasing power parity (PPP) basis that adjusts for price differences, China in 2016 stood as the largest economy in the world, surpassing the US in 2014 for the first time in modern history. China became the world's largest exporter in 2010, and the largest trading nation in 2013."

China is now a leader in the gross value of industrial output in industries including mining and ore processing of materials such as iron, steel, aluminium and coal. It also has the world's highest gross output of textiles, food, cement, automobiles, trains, ships and electronics to name just a few sectors.

A new plan

Inspired in part by Germany's Industrie 4.0, the Chinese premier at the time, Li Keqiang, launched a new strategic plan in May 2015 called Made in China 2025. The initiative is intended to comprehensively upgrade Chinese industry, making it one of the leading world powers.

> Made in China is intended to comprehensively upgrade Chinese industry, making it one of the leading world powers

It intends to do this by tackling the major challenges that the country still faces. According to the report by the State Council, published on 7 July 2015, "China's manufacturing sector is large but not strong with obvious gaps in innovation capacity, efficiency of resource utilisation, quality of industrial infrastructure and degree of digitalisation. The task of upgrading and accelerating technological development is urgent."

Another challenge is the dichotomy China faces as the result of industrial competition. On one hand, it must create new strategies for advanced manufacturing to compete with other developed nations. This involves not only promoting outward trade and investment but rethinking many ways of doing business.

On the other, it faces the squeeze from developing countries that are seeking to expand their share of industrial labour and low-cost manufacturing. The problem is that it will be difficult for China to simultaneously upgrade manufacturing quality, infrastructure and safety while keeping the cost of production and labour down.

> “Product quality is not high, and China has few world-famous brands”

And finally, the third biggest challenge faced by China is technology. According to the State Council report, "The capability for independent innovation is weak and external dependence for key technologies and advanced equipment is high. Enterprise-led manufacturing systems have yet to be perfected. Product quality is not high, and China has few world-famous brands. Resource and energy efficiency remain low, while environmental pollution is severe.”

Made in China 2025

The underlying philosophy that led to the creation of the Made in China 2025 concept stems from the desire to unburden China of its dependence on other countries for resources, research and technology.

The country wants to rid itself of the negative connotations associated with the term Made in China, to distance itself from the preconceptions people have about Chinese speed and replace it with an appreciation of Chinese quality. At the same time, it wants to establish Chinese brands that create a similar fervour to the likes of Western brands such as Apple and Google.

The underlying principles of Made in China include innovation-driven development, quality first, green development, structure optimisation and talent-oriented development. The first principle looks at making innovation the guiding theme of manufacturing and adapting institutions for innovation. The second aims to encourage enterprises to assume responsibility for product quality, the third principle puts sustainable manufacturing at the heart of future innovation.

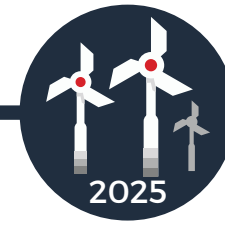
The principle of optimising structures seeks to support advanced manufacturing by upgrading industries, moving them away from product-oriented manufacturing towards service-oriented manufacturing. Finally, the talent-oriented principle seeks to develop talent as the foundation of manufacturing. Here, the programme wants to put in place mechanisms to improve the way people are hired, placed, trained and cultivated professionally, creating an atmosphere that supports an entrepreneurial mindset.

To bring these principles to fruition, Made in China 2025 has set up key milestones in four steps. The first step goes to 2020, the second step goes to 2025, the third to 2035 and the fourth to 2049.

Made in China 2025 The plan

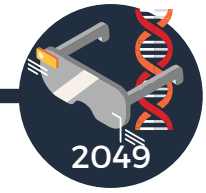
- Achieve industrialisation
- Consolidate manufacturing power
- Increase digitalisation
- Master core technologies in key areas
- Strengthen competitiveness in areas where China leads globally
- Improve product quality
- Reduce industry pollution

- Improve quality of manufacturing
- Improve capacity for innovation
- Improve labour productivity
- Integrate IT into industry at an advanced level
- Reduce energy & material consumption per unit of industrial added value
- Reduce pollution emissions of key industrial sectors to global standards
- Create industrial clusters to improve competition



- Help Chinese manufacturing reach the median level among global leaders
- Improve innovation capability
- Make breakthroughs in major areas
- Significantly increase overall competitiveness
- Lead global innovation in industries where China is not competitive
- Comprehensively realise industrialisation

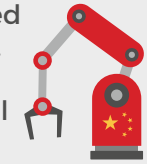
- 2049 will be the centennial of the founding of New China
- Consolidate manufacturing sector to become a leader among the world's manufacturing powers
- Have the capability to lead innovation
- Lead competitive advantage in major manufacturing areas
- Develop advanced technology and industrial systems



China in progress

One of the biggest drivers of industrial growth in China is automation. According to the International Federation of Robotics (IFR), worldwide sales of robots reached a new high of 380,550 units in 2017. China experienced the most growth, installing around 138,000 industrial robots — a 58 per cent increase compared to the previous year. Comparatively, South Korea installed 40,000 units; Japan, 38,000; the USA, 33,000; and Germany, 22,000.

> "China experienced the most growth, installing around 138,000 industrial robots"



The automotive sector continues to invest heavily in robots, something that is expected to continue as demand for electric vehicles continues to rise. Other growing sectors include the metal industry, electrical/electronics and the food industry.

Speaking at Automatica 2018 in Munich, Germany, Gudrun Litzenberger, general secretary of the IFR, explained that, "trends such as digitalization, robots that are easier to use, robots that learn from each other via the cloud, and improved human-robot collaboration will help continue the growth of worldwide sales."

Robots will not only become easier to handle and program intuitively, they will gain better analytical and machine learning skills. New-generation robots will also continue to offer flexibility for collaboration without protective barriers. As costs come down, this will open up the use of such robots to smaller businesses that have so far been limited in the choice of robotic platforms they can invest in.

Sourcing digital locally

China's aim to remove its reliance on foreign goods and services is also reflected in its plan. By 2020, it wants to source 40 per cent of all spare parts and materials domestically. This will impact advanced industries such as aerospace, aeronautical equipment, communications equipment, power generation and transmission equipment, engineering machinery, railway equipment and household appliances. By 2025, this will increase to 70 per cent of all parts and key materials being sourced domestically.

China has already made steps to begin this process. In May 2016, Chinese household appliance manufacturer Midea Group launched a bid to buy German industrial robot manufacturer Kuka for around €4.5 billion. Following approval by German market regulators, Midea now controls a 94.5 per cent voting stake in Kuka.

As well as sourcing locally, Made in China 2025 wants to increase exports of Chinese-made goods. The BBC's Karishma Vaswani explains that, "Ten key sectors have been targeted under this plan. Amongst the products they want to start exporting around the world include Chinese-made semiconductor chips, robotics, passenger jets and satellites, high-speed railways, ocean engineering from all the experience they've had building structures in the South China Sea and electric vehicles.

"To achieve these plans, the Chinese Government will give financial incentives to companies operating in these areas, invest money in research and development and Beijing will also push public institutions like universities and the military to co-operate more with private companies."

A solid future

China has outlined an ambitious roadmap for the next three decades and made strides towards achieving this, not least by building a world leading economy. While the country still faces challenges with heavy intervention from Beijing and competition from both developed and developing economies, the technological progress in China is incessant. A country that is regarded as one of the five cradles of civilisation — regions that incubated human civilisation — has risen once again and is building a solid future for digitalisation.

The workforce of the future

An interview with
Beyang Arrey & Laura Brown:
two female engineers from Renishaw

In its 2018 synopsis, Engineering UK explains that, "In the face of technological advancements and a changing political and economic landscape, developing the pipeline to address the skills needs of the engineering sector remains a key challenge". Part of the reason stems from the fact that only eleven per cent of the UK engineering and technical workforce is female, according to research by the IET. To delve deeper, here, we talk to two female engineers from Renishaw.

Beyang Arrey is a software engineer and Laura Brown is a mechanical engineer in Research & Development at Renishaw's Additive Manufacturing Products Division (AMPD). Renishaw is a world leading engineering technologies company, supplying products used for applications as diverse as jet engine and wind turbine manufacture, through to dentistry and brain surgery. It has over 4,500 employees located in the 36 countries where it has wholly owned subsidiary operations. For the year ended June 2018 Renishaw recorded sales of £611.5 million.

EU Automation: One of the reasons that's often cited for a lack of female engineers in industry is the inherent gender-bias in school subjects, which are taught from a young age. For example, the idea that certain subjects are for boys and others for girls. Was this true when you were at school?

Laura Brown: I didn't feel any bias myself. Although, when I studied maths and physics there were only two girls in the class.

Beyang Arrey: I went to an all-girls school, so everyone did all the subjects. Although, in high school, there were noticeably fewer students choosing the technical subjects than the arts classes.

What were your perceptions of the world of engineering when you were at school?

Brown: I didn't know what it was. You don't really get taught about what engineering is at school. People thought it was what mechanics did when they fix cars.

> **“You don't really get taught about what engineering is at school. People thought it was what mechanics did when they fix cars”**

Arrey: I didn't really want to be an engineer when I was young. My dad is a civil and structural engineer, so I had some idea what the job involved, but I didn't aspire to be one myself, until I was studying for my AS Levels.

You were obviously among the women that weren't affected by pre-conceived notions of the industry. So, what inspired you to pursue an engineering career?

Arrey: I was originally planning on going into the medical field, but when I was in high school, I couldn't handle the blood during dissections in biology. I had to do something else. Back home in Cameroon we had an old TV and VCR that I enjoyed tinkering with. My mum suggested that I do an online survey for a career and possibly look at computer engineering.

My mum really helped me with the application process. She did some research online and got me some UK application forms. We also had some ambassadors from UK universities come into school to promote their institutions, which got me thinking about studying engineering in the UK.

Brown: I didn't always know that I wanted to be an engineer. I really enjoyed studying maths and physics at A Level and particularly the mechanical side of things, so I decided to give it a go.

I did some work experience at the company my dad worked at and really enjoyed it. It's a company called Sonardyne and it is a global provider of underwater acoustic, inertial, optical and sonar technology. It's a bit like GPS technology to help engineers lay things like pipelines and test rigs underwater. I did that during the summer between my AS and A-Levels and it inspired me to pursue a career that involved problem solving in an engineering discipline.

> **“I kept my module choice quite broad, before specialising in 3D printing and additive manufacturing (AM)”**

Can you tell us about your journey to become an engineer? What subjects did you study, what work experience did you do, what does your current role involve?

Brown: I did an integrated master's degree in mechanical engineering at the University of Manchester. I kept my module choice quite broad, before specialising in 3D printing and additive manufacturing (AM). It's a fascinating technology and I wasn't aware until later that it could be done with metal. I was still working at Sonardyne when it bought its first 3D printer, which made me more interested to learn about how the technology can be used.

While at university, I looked at different providers of additive manufacturing hardware and software and I came across Renishaw, the only registered British manufacturer of metal additive manufacturing systems. I Googled the company, found the relevant section on the website that I was specifically interested in and applied. I did well in the interview — they said I was a great communicator — and I joined the company's graduate scheme as a mechanical design engineer.

Today, I'm doing more of a systems development role, which is about integrating control system software into a variety of hardware. I define the user requirements and look at how the whole system functions; testing software, defining what we need and problem solving. When we have a new product, we need to define how the software is going to behave.

For example, if we need a valve to open when the user presses something, then we need to test it to ensure that there are no bugs in the code. If there are, we would then go back to the software team to work out what to change. We want to prevent any problems with hardware and software from getting into the field.

Arrey: I did my degree in computer systems engineering at the University of Birmingham. The first year and a half involved focused study on electronics, electrical engineering and computer programming. For the second half of the degree programme, you could then decide if you wanted to go towards the electrical and electronic or computer side. For me, computers were more interesting because of the digital arithmetic so that's what I chose.

When I finished my bachelor's degree (BEng), I had the option of going on to study for a PhD, and that was certainly what my parents were keen for me to do. However, I didn't want to study for another four years. Instead, I did a masters, which required six months in industry and since I didn't have previous work experience in the UK that was relevant, it was the perfect opportunity to improve my chances of getting a job afterwards.

I did work experience at Renishaw's Charfield site in Gloucestershire, where much of the software development work is carried out. This came about because one of my lecturers knew of Renishaw and later added it onto the University's affiliated companies list. Out of all the companies, Renishaw had the shortest application process - I was invited to an interview after filling in a short online application. Other companies may have five or six steps and even waiting for feedback between each step in the process can be long winded.

> **“For me, computers were more interesting because of the digital arithmetic so that's what I chose”**

Brown: As a graduate engineer, you're often keen to get started and continue learning on the job, so the intensity of the recruitment process can put many people off. I spent days filling in online application forms that weren't at all user friendly. Sometimes they even time out after twenty minutes so you don't have long enough! When we've got a shortage of engineers in the industry, this is the last thing we need, so I'm glad the process at Renishaw was simple.

Arrey: My work experience focussed on embedded programming, which involves programming microcontrollers to run a certain task. Part of that involves being able to meet industry standards for equipment that operates in harsh conditions where data transmission might be subject to losses, so you must build in data redundancy to ensure the data integrity. During this time, I also used C programming for surgical equipment in the medical sector.

After I graduated, I applied to Renishaw for a position. My work experience was a real asset and after a short interview process, I was offered a job.

After accepting the position, I applied for a Visa to work in the UK, confirmed a start date and moved to Stafford, close to Renishaw in Stone. In the beginning my role was still in software, but I was increasingly working closely on the control systems that run the additive manufacturing machinery. I spent three years working with colleagues on the code for the AM software before moving into my current role, which is more abstract. I no longer work directly on the software for AM machines, rather I work on products related to the running of builds on the machine.

> **“I didn't have previous work experience in the UK that was relevant, it was the perfect opportunity to improve my chances of getting a job afterwards”**

For example, I look at software that helps our users verify the characteristics of how the AM process interacts with the raw material. A material file can then be produced that precisely and consistently generates the required material properties.

Industry across the world faces a technology and engineering skills shortage, where the increased use of automation and digitalisation technologies such as AI, AR, VR and AM will require graduates with new digital skills. In your current role, what new skills have you had to acquire and what skills will future graduates need to possess?

Brown: Having never done software programming before, I've been exposed to a lot of industrial programming such as PLC code. There is a real shortage of engineers familiar with software and there is certainly a shortage of software skills. When you're at university you learn about the theory, but you don't get to extensively build the skills you need in industry.

> "There is a real shortage of engineers familiar with software and there is certainly a shortage of software skills"

I had previous experience of designing parts, but I had to learn about things like tolerance stacking — that's the idea that because nothing can be made perfectly, it's important to measure how imperfect a part is. So, in AM, we have to understand the tolerance of a part that might be used in something like aerospace.

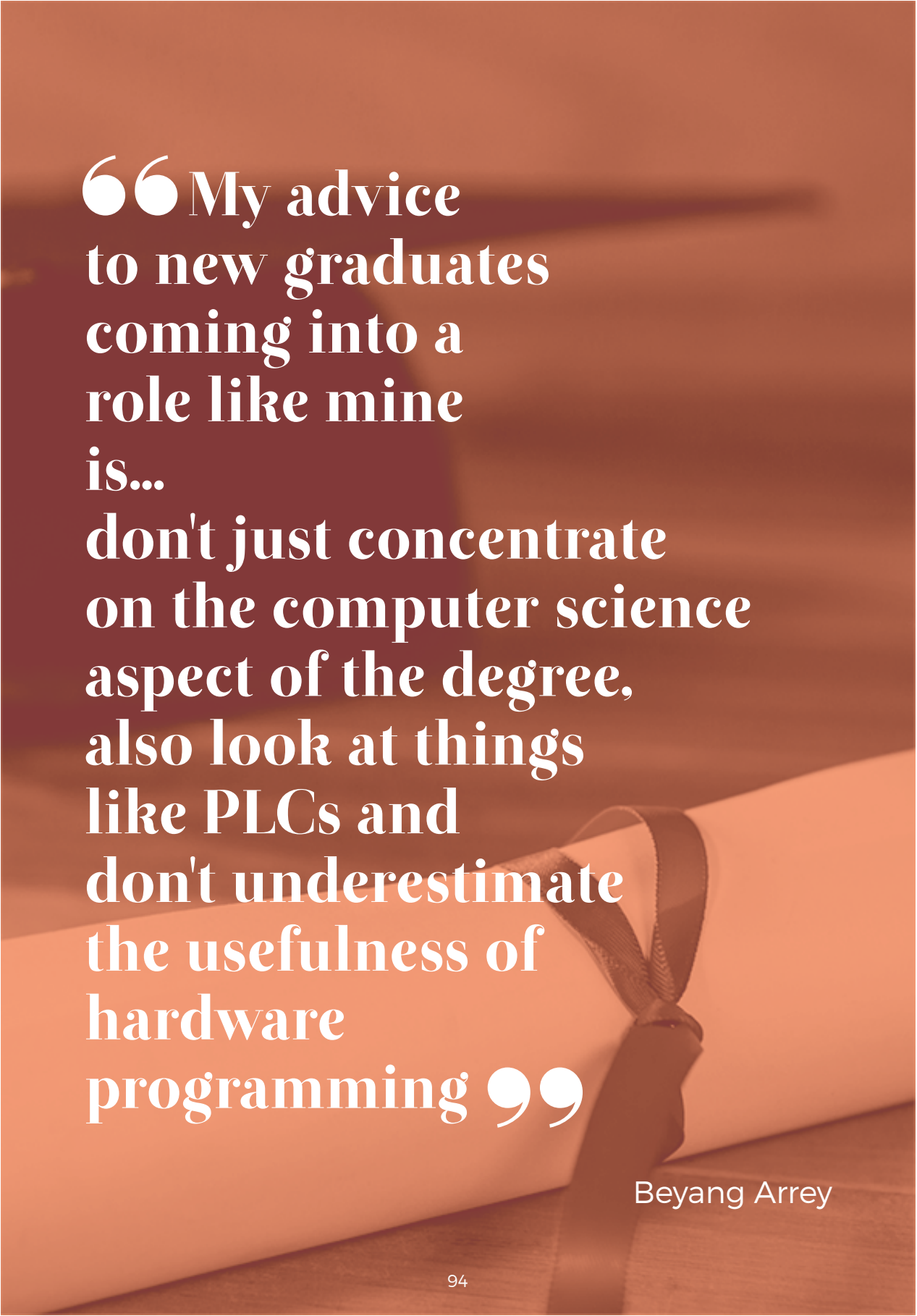
The integration of control systems is another area that isn't covered well in a mechanical engineering degree. Using sensors to control flow rates or heater temperature is important to learn. Despite not being exposed to PLC code, I now use it on most days in my job to test things.

Renishaw is excellent at delivering training programmes. We're encouraged to carry on learning and we can take out courses on subjects of our choice. For example, we've recently organised a PLC course to cover new programming languages. I think degree courses need to become more varied to cover areas like software in a mechanical engineering degree. You can't expect a mechanical engineering graduate to come out of university and only do mechanical work, so why not teach them other areas they may need?

> "The integration of control systems is another area that isn't covered well in a mechanical engineering degree"

Arrey: When I started working in AM, I had to work in a scripting language called Python. While I'd been introduced to it at university, we never actually used Python for control systems, we were only taught the basic syntax of the language and nothing more, even though it is one of the most popular scripting languages. I've since had to learn the ins and outs of it on the job and went to Bristol to do a Python course that was paid for by Renishaw. We also went to Renishaw's Charfield site where we learned about Agile project management techniques and product cost management (PCM) tools and techniques, which has been helpful in our day to day work with stakeholders to define control system requirements.

My advice to new graduates coming into a role like mine is don't just concentrate on the computer science aspect of the degree, also look at things like PLCs and don't underestimate the usefulness of hardware programming.



“My advice to new graduates coming into a role like mine is... don't just concentrate on the computer science aspect of the degree, also look at things like PLCs and don't underestimate the usefulness of hardware programming”

Beyang Arrey

According to a survey by the Institution of Engineering and Technology (IET), only eleven per cent of the UK engineering and technical workforce is female. Most industry experts agree that supporting young girls and making engineering more attractive to female students will go some way in reducing both the gender and skills gap. You are both also Science, Technology Engineering and Maths (STEM) ambassadors at Renishaw, what does this role involve?

Brown: It mostly involves going into schools and talking to secondary-age students and educating them about what engineering is. The perception is that it is male dominated and a very manual, hands-on job. This is where I can tell them that you can make of engineering what you want. We also do demonstrations with things like Lego where we can build simple assembly lines or make a battery spinner to explain how a motor works. The children may not have seen these kinds of demonstrations in their maths and physics classes, so it has a lot of impact.

> "The perception is that it is male dominated and a very manual, hands-on job"

Girls often tell me they didn't realise that this is what engineering was like and that they haven't seen any other female role models. I was quite inspired by strong female figures such as Ada Lovelace who was the first ever computer programmer, so I want to pass on this passion for engineering to the next generation and act as a role model.

Arrey: My STEM ambassador role also involves going into schools and careers fairs. Last year, I went into a school here in Stone. It was a secondary school where I delivered a presentation on what engineering is, what software engineering is and what Renishaw does. I like to take additively manufactured parts that show the intricate lattice structures, as these are a visual way to introduce the benefits of the technology. I also took a human skull with metal implants that were additively manufactured to show how engineering can be applied to healthcare. The students usually pass this around and it gets them excited because it's something they've never seen before.

> "I also took a human skull with metal implants that were additively manufactured to show how engineering can be applied to healthcare"

I also talk students through my typical work day and ask them about what skills they think are required. For secondary school children, I emphasise the need for strong English skills as well as maths skills. Being good with numbers is only half the battle, being able to communicate and express yourself using good language skills is just as important when capturing project requirements. I typically find that girls can initially be quite shy, but they soon relax, and both the boys and girls ask great inquisitive questions.

In addition to my role as STEM ambassador at Renishaw, I also work with a charity in Cameroon that goes into primary schools to raise awareness of STEM and I'm also part of the IET in Birmingham, which works with universities to organise networking events and competitions to encourage young professionals.

Young people need to be aware that as a female engineer you often have to work much harder than your male counterparts, that gender bias still exists and sometimes this might be an unconscious glass ceiling, so you really have to prove your competence.

What would be your advice to young girls considering a career in engineering, or those that may be unsure about what options are open to them?

Brown: By the time girls are considering engineering, our work is done. My advice would be that if you're considering it, do some work experience, see what you like and don't like and then find your niche within the industry.

Arrey: Give it a go. The best way to go about it is that if you're unsure, do some work experience, even a few weeks or months in an engineering company will open your eyes to it. Once you've tried it, you'll know for sure.

> **“You don't have to go to university either, you can do apprenticeships and I think that's what Renishaw is good at”**

Brown: Renishaw offers work experience schemes. The sites at New Mills in Gloucestershire and Miskin in South Wales offer one-week sessions where you can work in groups with a variety of people. Here, you'll get a chance to create a product and experiment with the technology. You don't have to go to university either, you can do apprenticeships and I think that's what Renishaw is good at, you're treated equally, and we'll see these kinds of scheme gain more popularity in the future as a route into the industry.

14

Using obsolescence to your advantage

The first steps to digitalisation don't have to be painful

As a plant manager, you want to digitalise, but you're reluctant to overhaul your entire plant and all the equipment in it. You know that downtime is a killer of productivity and you can't afford to keep equipment idle. At the same time, you know that investing in new machinery with all the latest bells and whistles is bound to improve efficiency and reduce your maintenance costs.

The problem is, you can't justify the expenditure to your seniors who are highly focused on delivering a fast return on investment. And anyway, you ask yourself, what if that new equipment isn't compatible with my existing setup — and won't I need a specialist to install it?

> **“It's right to consider the tangible and intangible financial benefits before taking the leap of faith”**

If this is what you've been thinking, you would be forgiven for doing so. It's right to consider the tangible and intangible financial benefits before taking the leap of faith. But what if it doesn't have to be a leap? What if it's more of a step, a small step, in the right direction? Something that can give you the benefits of internet connectivity and remote diagnostics, without the expense of buying a new motor or variable speed drive. Well, there is an answer and it comes in the form of retrofitting.

Obsolescence

As consumers we've come to expect devices like our smartphones to be updated every year. This is having a knock-on effect on industrial product lifecycles too, which are becoming shorter and shorter. While this seems good in the short term — after all, who doesn't want their equipment to be fitted with the latest features? — it makes equipment obsolete faster than necessary.

An obsolete part is one that is no longer manufactured. The part itself may still work well in the plant, but when it reaches the end of its life, the plant manager cannot simply go back to the original equipment manufacturer (OEM) for a direct replacement. In this situation, there are a few options. The first is to upgrade the entire system with brand new equipment. However, this is usually the costliest method and would mean the plant having to replace other perfectly good, working equipment.

> **“Despite what you might think, sourcing spares doesn't mean you have to buy defective parts”**

The second option is to find a like-for-like replacement. Despite what you might think, sourcing spares doesn't mean you have to buy defective parts. By working with an industrial automation parts supplier like EU Automation, manufacturers can ensure they get their lines up and running as quickly as possible with a high quality reconditioned, refurbished or new part.

In an article published in the June 2017 edition of Electronics Sourcing, the magazine explains that, "The rate of component obsolescence has increased over the last 15 years, but component manufacturers are doing a better job of notifying buyers when they plan to discontinue a part.

“The increase in obsolescence impacts some industries more than others. Industries with short product lifecycles, such as smart phones, are not impacted as much as industries with longer lifecycles such as defence and aerospace, medical and industrial equipment. Products in those industries can be built for 20 or more years and outlast the lifecycles of some of the components that the products use.”

> “The rate of component obsolescence has increased over the last 15 years, but component manufacturers are doing a better job of notifying buyers”

Retrofit your future

With this in mind, it's important that manufacturers effectively manage and plan for obsolescence. One way to do this that will become increasingly important in the coming years is retrofitting, which gives legacy equipment new features by adding modules or peripheral plug-and-play devices.

Old machines can be given a new lease of life by adding features such as internet connectivity, expandable memory or a protocol converter for interoperability between proprietary systems.

This could take the form of a smart sensor that adds remote condition monitoring to a motor or a new high bandwidth module that adds a terabit ethernet connection or high speed 5G cellular connectivity to the plant.

Retrofitting measures can extend to devices like PLCs and HMIs. As well compatibility with protocols such as PROFINET, Profibus and Modbus, new PLCs can facilitate high-speed motion control and real-time reporting. Combined with HMIs, they can also allow plant managers to create digital twins and 3D simulations to virtually commission new equipment while providing energy management for the whole plant.

> “Digitalisation doesn't have to be a drawn out or painful experience”

Other companies, such as automation specialist B&R, are offering all-in-one boxes: "As an Industrial IoT solution package, the Orange Box brings smart-factory intelligence to brownfield [existing] installations. It is now possible to read and analyse data from previously isolated machinery and equipment. A controller collects runtime data via I/O or fieldbus and processes it using intelligent software components. The greatest advantage is that there's no need for any changes to existing hardware and software.”

It's clear that digitalisation doesn't have to be a drawn out or painful experience. Using obsolescence to your advantage is vital. By taking small steps to update their plant and equipment, manufacturers can begin their journey to digitalisation.

EU Automation is a rapidly growing business that was established in 2009. The company is an industrial automation parts supplier that delivers new, repaired, reconditioned and obsolete parts to companies around the world. EU Automation has customers in 145 countries and supplies parts from 127 manufacturers. Parts are delivered within nine hours anywhere in Europe and dispatched the same day for international orders.

15

Future foresight

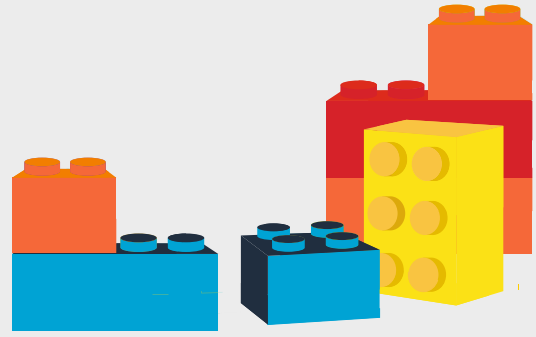
EU Automation's Jon Wilkins predicts the future of digitalisation

Jonathan Wilkins is marketing director of EU Automation and one of the most prolific writers on industrial automation. He is a professional brand advocate and commercial marketing strategist, who has been part of the EU Automation team since its humble beginnings.

Here, he looks at the industrial automation trends and technologies that will become a reality in the coming years.

Modular automation:

Plants and factories can take years to design and build. Once they're up and running, it is difficult to modify the setup to customise it for different manufacturing needs. Modular automation will introduce smaller, self-contained building blocks that can be joined together to scale up and scale down production depending on the type and volume of product being manufactured.



IoT on the Edge:

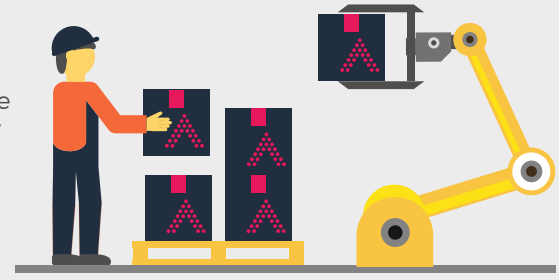
As the cost of sensors continues to fall, we will see the increased use of IoT devices strengthen edge computing. This will blur the lines between where one system stops, and another starts.

AR glasses:

Many companies have attempted and failed to introduce augmented reality glasses into consumer markets. Instead, AR glasses will find popularity on factory floors, helping maintenance engineers make repairs more quickly.

Deep learning:

We've seen the transition of robots from cages to desktops in the last few years. Now that automated systems are working collaboratively alongside their human counterparts, the next stage will see deep learning AI extend to plant networks. Machine vision, object and speech recognition and plain text reporting will improve as a result.



Usable analytics:

Big data is only as useful as what you can do with it. Collecting more valuable data and combining it with cloud analytics platforms will give anyone in the business, with any skill level, an easy understanding of what's going on. It will also tell them what actions they need to take and at what time.

AGVs:

Automated guided vehicles will not only be used to transport goods across the factory, they will be used to create semi-autonomous production lines. This will speed up the highly labour-intensive process of making parts like wind turbine blades or aeroplane wings, which must be constantly repositioned in staging areas during production.

Integrated platforms:

Information technology (IT) and operational technology (OT) will continue to converge. Business programs like CRM and ERP systems will cross over with MES and MRP programs to improve the efficiency with which manufacturers make products and supply chains communicate.

Open platforms:

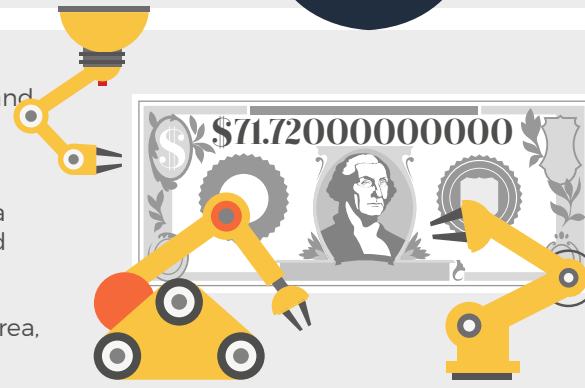
Proprietary platforms and architectures will become increasingly standardised. This will affect fieldbus protocols being replaced with industrial ethernet and OPC UA being adapted to work across IoT and cloud devices.

New digital jobs:

Data scientists will analyse and model data, for example by creating digital twins and improving asset performance. Data engineers will use this information to make changes to control systems in real time. We will also see the role of chief information security officers (CISOs) encompass cybersecurity management.

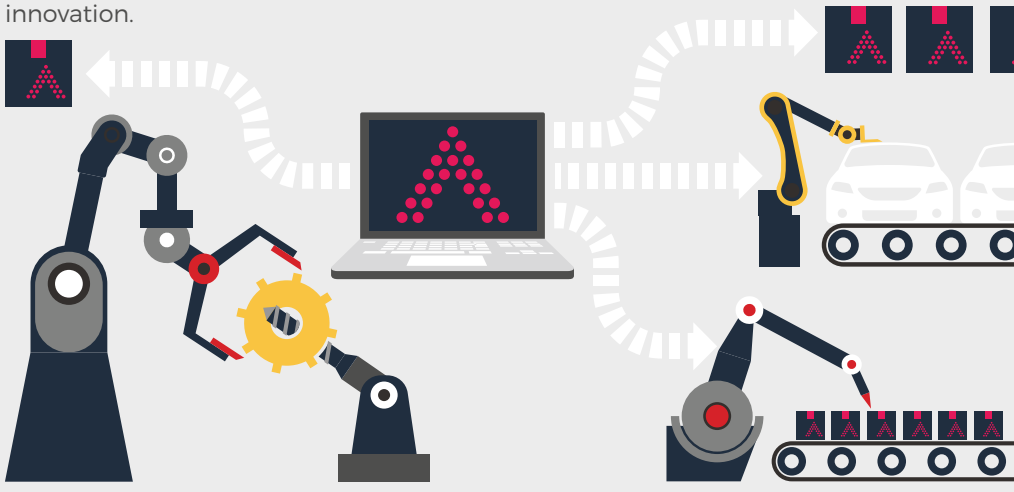
Varied robots:

According to research by Markets and Markets, the robotics market will experience a compound annual growth rate (CAGR) of 9.6 per cent between 2017 and 2023, reaching a value of $71.72bn. Collaborative and autonomous robots will drive this growth. China will lead robot sales, followed by countries including Korea, Japan, the US and Germany.



More Industry 4.0:

Countries around the world will continue to develop policies, programmes and initiatives to drive awareness and adoption of Industry 4.0 technologies. Digital transformation will become a mainstream phenomenon, further accelerating innovation.



Powered by:
www.euautomation.com

It’s not easy being a manufacturer in today’s world. Consumer tastes are changing, product lifecycles are getting shorter and there are now more technologies than you can shake a stick at. Oh, and if you don’t digitalise immediately, you’ll be left dead in the water. No wonder, then, that so many businesses are scrambling to use industrial digital technologies such as additive manufacturing, artificial intelligence, remote monitoring and cloud analytics.

This book explains how different phrases such as Industry 4.0, Society 5.0, Made in China 2025, L'usine du Future and digitalisation have all come to represent different faces of the same Industrial Revolution. We review everything from smart manufacturing, the changing face of the workforce in light of automation and change initiatives supporting industry around the world. The Fourth Industrial Revolution is here, and this book tells you what you need to know.