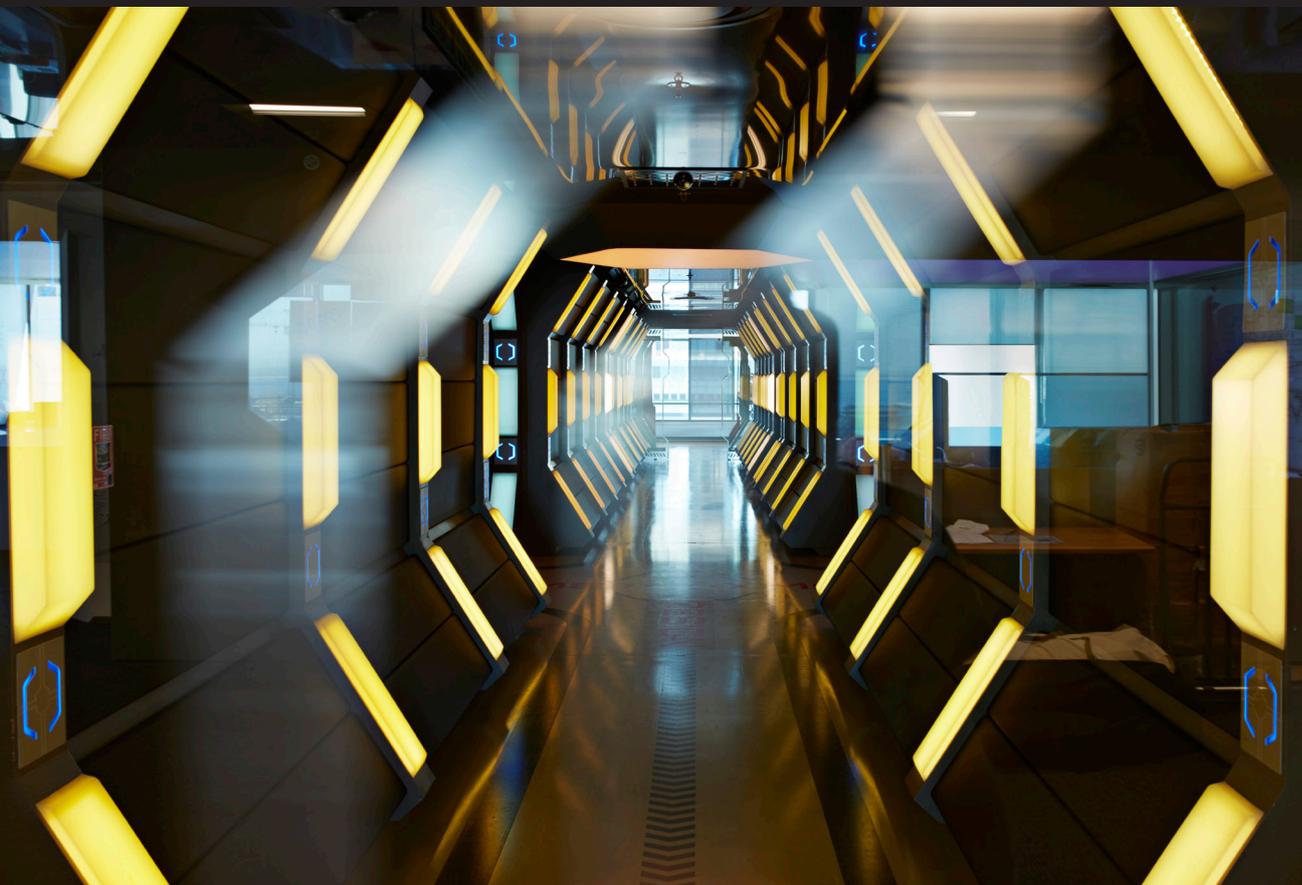


Defining the new DNA of industrial digital organisations

The CEO's agenda

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Foreword

Digital transformation starts at the top

The Fourth Industrial Revolution is a phenomenon that is taking place as we speak, and is happening so quickly that it is not always easy to determine its impact or how best to react to it. As the expression goes, sometimes it is hard to see the wood for the trees.

Adopting widespread digital transformation within an organisation is not something to be undertaken lightly. Considering the upfront capital investment involved, it requires thorough and well considered analysis of every process within the organisation before proceeding with implementation. Yet, such is the pace of change that, no sooner has this process been completed, the technology may well have moved on.

Nevertheless, as challenging as it might be to get to grips with this new reality, business leaders must not be discouraged from trying. In fact, those organisations that fail to modernise will inevitably struggle to compete, and even to survive. In short, adapting to the new realities of the Fourth Industrial Revolution requires a change in mind-set, and indeed in the DNA of an organisation. This is no walk in the park.

The Defining the new DNA of industrial digital organisations: The CEO's agenda report by PwC provides a useful road map for CEOs of manufacturing and industrial companies contemplating embarking on organisational change of this magnitude. It identifies four initiatives that should be carried out in tandem to prepare an organisation for the new digital age.

As the report makes clear, adaptation to the ongoing changes brought by the Fourth Industrial Revolution requires that profound organisational change starts at the very top and filters right the way down into every corner of a business, if that business is to reap the maximum rewards and achieve a return on the initial investment. Thus, strong leadership is an essential component if manufacturing is to truly harness the potential of the Fourth Industrial Revolution.

Secondly, organisational change must extend to identifying and hiring a workforce that is not only equipped with the right skill set, but is also committed to lifelong learning, as the Fourth Industrial Revolution demands. Thirdly, industrial companies will need a change of mindset to think more like software businesses, with the ability to quickly adapt and optimise their processes. Lastly, digital transformation must extend beyond IT to include operational technology (OT).

The Global Manufacturing and Industrialisation Summit (GMIS) was established to provide a forum and a platform where leaders from across manufacturing, industries, governments, technology and academia can share their ideas, knowledge and experience so that the industry can navigate the challenges and opportunities that arise through the introduction of Fourth Industrial Revolution technologies.

The summit aims to create a road map for the transformation of the manufacturing sector, and build global, inclusive prosperity, in line with the Sustainable Development Goals.



Badr Al-Olama
Head of the Organising Committee,
Global Manufacturing and Industrialisation Summit (GMIS)

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Executive summary

Digitisation is revolutionising the way we work, the skill sets we need and the way we structure our organisations. Manufacturing organisations have begun to realise the role digitisation must play in improving their performance, with data, integration and problem solving as the core drivers.

Already, digitally 'smart' manufacturers are gaining a competitive advantage by exploiting emerging technologies and trends such as digital twinning, predictive maintenance, track and trace, and modular design. These companies have dramatically improved their efficiency, productivity and customer experience by ensuring these capabilities are central to their operating models and by matching them with strong skill sets in analytics and IT.

During 2018 and early 2019, PwC conducted in-depth digitisation case studies of eight industrial and manufacturing organisations in Germany, the US, India, Japan and the Middle East. Drawing on discussions and interviews with CEOs and division heads, we explored the key triggers for change these companies faced, assessed how digital solutions are being implemented and how digitisation is affecting key aspects of their operating models. We also compared our eight organisations with other publicly cited digitisation case studies, and leveraged PwC's 2018 study *Digital Champions: How industry leaders build integrated operations ecosystems to deliver end-to-end customer solutions* and other ongoing PwC research. We also look ahead to the second part of this study, which will be published in January 2020.

Based on our research, we identified four changes CEOs must implement to maximise the benefits of digitisation:

- Drive organisational changes that address new digital capabilities and digitised processes from the top.
- Hire more software and Internet of Things (IoT) engineers and data scientists, while training the wider workforce in digital skills.
- Learn from software businesses, which have the ability to develop use cases rapidly and turn them into software products.
- Extend digitisation beyond IT to include significant operational technologies (OT) such as track-and-trace solutions and digital twinning.

This paper is the result of ongoing collaboration between PwC and the Global Manufacturing and Industrialisation Summit (GMIS). GMIS provides a forum for industry leaders to interact with governments, technologists and academia in order to navigate the challenges and opportunities brought about by the digital technologies of the Fourth Industrial Revolution. PwC has been a knowledge partner with GMIS since 2016.

Disrupting the future

Why digitisation is reshaping the manufacturing industry

Manufacturers around the world face growing pressure from customers, governments, competitors and emerging technologies to digitise their organisations.

Consumers increasingly want higher-quality, digitally enabled products at a lower cost that are adapted to their specific needs. In response, companies are having to develop and manufacture customised, digitised products on tighter deadlines and budgets, while retaining sufficient flexibility to meet constantly changing design specifications.

New regulations are also pushing manufacturers to accelerate digitisation initiatives in order to remain compliant. For example, digital monitoring and data analysis help companies meet track-and-trace requirements for products and sustainable development goals in areas ranging from product design to energy-efficient manufacturing.



Case Study 1:

A German chemicals conglomerate

The challenge

A global chemicals conglomerate based in Germany wanted to be an industry leader in innovative digitisation.

The solution

A robust digitisation strategy was developed that covered smart supply chains and manufacturing processes, digital business modelling and innovation. The company formed joint projects with innovative technology providers, including startups.

Key results

- Smart supply chains incorporating AI-driven analytics and a transparent shipment-tracking platform, part of the digitised horizontal value chain
- Digital twinning that replicated physical assets, resulting in a paper-free shop floor and predictive maintenance systems, reflecting innovations in the vertical (or internal) value chain

Key takeaways

- Detailed digitisation strategy
- Comprehensive training in digital skills
- Collaboration with innovative external partners

Case Study 2:

A Japanese automotive supplier

The challenge

A Japanese automotive components manufacturer and supplier was being challenged by customers and competitors to reduce set-up time and increase plant uptime, which were affected by poor maintenance. In addition, the company needed to improve safety.

The solution

Cameras and sensors were installed in cranes, machine tools, inspection equipment and other machinery to enable the collection and analysis of data regarding maintenance needs and accident prevention. To encourage workforce engagement, operators were involved in the design of digital processes.

Key results

- Review of production variables to understand their impact on quality and productivity
- Processing and analysis of large volumes of real-time data to facilitate rapid, efficient problem solving
- Quality monitoring and verification of manufacturing and operating systems, enabled by similar data processing and analysis

Key takeaways

- Data processing and analysis were used to design experiments that maximised the efficiency of core manufacturing and supply chain operations
- Scalable digital systems allowed replication across other plants
- Smart automation compensated for gaps in workforce skills

Advances in information technology are reinforcing the pressure on manufacturing organisations to digitise so they can avoid falling behind the new breed of market-leading ‘digital champions.’¹ In recent years, sophisticated software and communication tools have enabled remote real-time collaboration on a multitude of both simple and complex industrial tasks. On the shop floor, the use of IoT sensors eliminates frequent status inspections and facilitates process-control automation. The collection and analysis of large volumes of data can also increase the efficiency of manufacturing equipment and reduce bottlenecks.

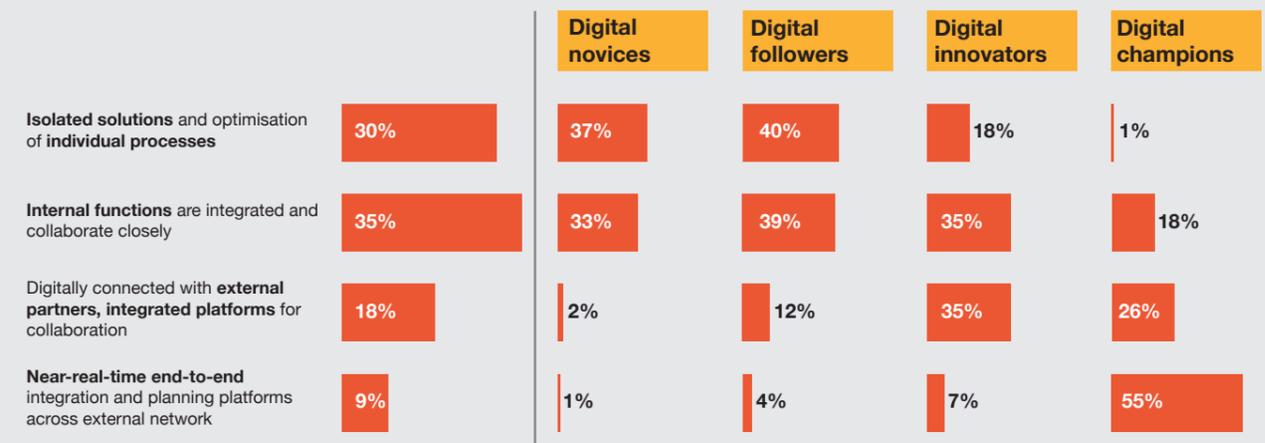
Against this backdrop the rapid introduction of digital applications and tools in manufacturing is disrupting traditional corporate hierarchies and roles (see Figure

1). Manufacturers increasingly value data scientists, software engineers and computer science graduates, and digitisation is dissolving barriers between functions within organisations. For example, the progressive digitisation of product development and production means manufacturing, supply chain and design functions are becoming more integrated, as we explain in PwC’s 2018 Global Digital Operations Study.² Tasks such as Design for Manufacture (DfM) and Design for Assembly (DfA) are being transformed by advanced CAD (computer-aided design) and CAM (computer-aided manufacturing) software, which make the designer more efficient while improving the product’s quality and design.

Fig. 1: Digitisation is dissolving barriers between functions within manufacturing organisations

Level of horizontal integration across supply chain functions

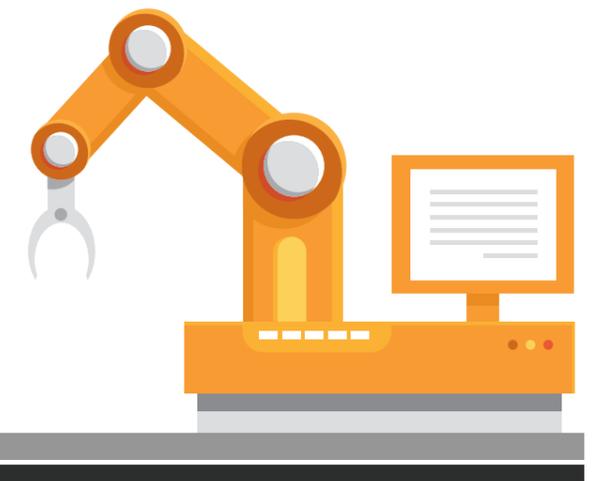
Question: **Which statement best describes your supply chain? Please select only one.**
Survey of 1,155 manufacturing executives in 26 countries



Note: Sums may not total 100 due to missing responses. Please refer to page 18 for the definitions of digital novices, digital followers, digital innovators and digital champions.

Source: PwC’s Global Digital Operations Study, 2018. *Digital Champions*.

Digital and other emerging technologies are also transforming the performance and mind-set of manufacturing employees, as PwC noted in its 2017 study *The workforce of the future: The competing forces shaping 2030*. Overall, the expanding role of data, analytics and AI at every operational level is changing assumptions about what constitutes routine work and what skills are critical. Many tasks will become automated, and the best workers will need to combine technology skills with problem solving and innovation.



¹ PwC’s Global Digital Operations Study, 2018. *Digital Champions*.

² PwC’s Global Digital Operations Study, 2018. *Digital product development 2025: Fast, efficient and customer centric*.

Case Study 3:

An aerospace parts supplier

The challenge

A Tier Two aerospace supplier based in the Middle East and North Africa (MENA) region had relatively advanced digitised manufacturing technologies. However, some of the company's operations were still manual, and the company believed that its digital processes and IT architecture were not well integrated in certain areas, such as production planning.

The solution

Senior management asked the company's operations, finance and technology teams to undertake a comprehensive digital transformation drive.

Key results

- Real-time, integrated supply-and-demand operations planning across all supply chain partners
- End-to-end track-and-trace solutions for products, tools and employees
- End-to-end integrated production planning for improved asset utilisation and cost-effectiveness
- Digital quality-assurance systems combined with nondestructive product testing

Key takeaways

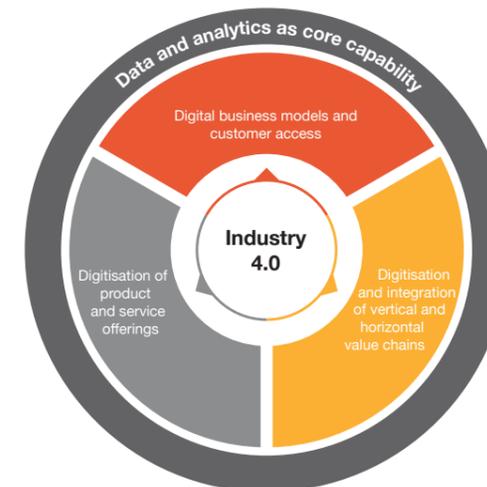
- Horizontally integrated value chain created an end-to-end supply chain network
- Digital twinning and data-driven planning tools helped integrate and optimise operations
- Connection of IT and operations technology through software integration
- Training of digitally smart workforce familiar with Industry 4.0 skills and tools

The results of our study: How digitisation is changing the DNA of manufacturing organisations

Digitisation will have a sustained impact on operational and business processes as emerging digital technologies enable the creation of new processes, products and business models — and ultimately forge digital enterprises (see Figure 2). For example:

- Manufacturing execution systems (MES) are enhancing automation, traceability and centralised control.
- Digital twinning and simulators are facilitating more efficient and cheaper product development and creating models for new services.
- Predictive maintenance and smart robots allow operations to monitor and manage their own health and order spare parts in good time.
- Digital inventories and radio frequency identification (RFID) tags are improving production control, lead-time analysis and capacity planning.

Fig. 2: Digital enterprises consist of digitisation and integrated processes, products and business models



Source: PwC's Global Industry 4.0 Survey, 2016. *Industry 4.0: Building the digital enterprise.*

Case Study 4:

A European global oil and gas conglomerate

The challenge

A multinational European oil and gas conglomerate was eager to improve the management of offshore assets, including rigs.

The solution

From 2016 to 2018, the firm partnered with an engineering modelling and simulation technology company and engineering R&D experts for a cyber-twinning initiative. Cyber-twinning was deployed to determine the viability of drilling and extraction projects, gather real-time data about the state of assets and help detect early signs of maintenance needs.

Key results

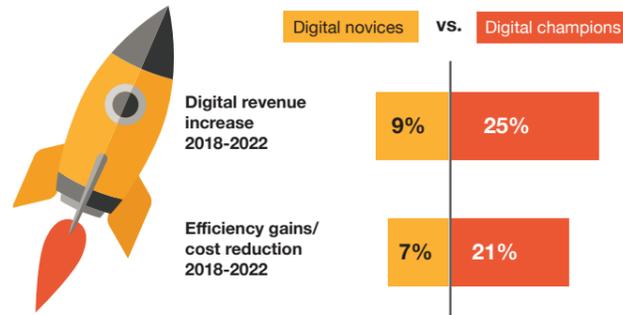
- Utilisation of a process mining tool to provide benchmark analysis and enhance operational processes for hydrocarbon management
- Training sessions to ensure the workforce understood the objectives for utilising the tool
- Identification of projects to improve management of offshore assets
- Company-wide asset optimisation, supported by IoT sensors, data analytics, data visualisation and related tools

Key takeaways

- Digitisation requires a corresponding culture shift, achieved by communication and training
- Predictive maintenance requires a significant upgrade in physical and virtual science skills such as electromechanical engineering and data analytics

From the shop floor to the boardroom, digitisation releases fresh revenue streams by driving innovation and increasing efficiency (see Figure 3).

Fig. 3: Companies proficient at digitisation increase revenues while boosting efficiency and realising cost reductions



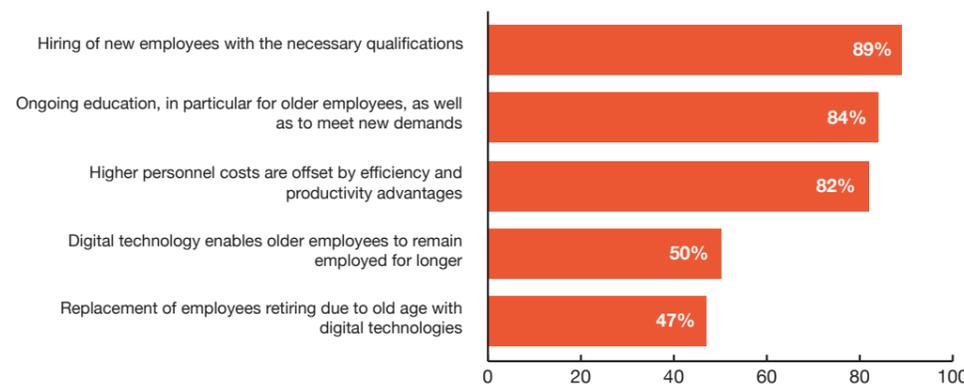
Source: PwC's Global Digital Operations Study, 2018. *Digital Champions*.

Our survey of eight industrial and manufacturing organisations in Germany, the US, India, Japan and the Middle East reveals how digitisation is transforming these companies' DNA. Key changes include:

- Seamless, data-driven vertical connections within a single organisation
- Integrated systems and efficient decision making, both internally and between companies participating in the same end-to-end supply chains
- Significant restructuring of personnel, operations and manufacturing processes due to the introduction of digitised products and services (see Figure 4).

Fig. 4: Digitisation will have a significant impact on the manufacturing workforce

Question: **What do you expect for your company as a result of digitisation?**
Base: Survey of 200 manufacturing executives



Source: PwC, 2017. *Digital factories 2020: Shaping the future of manufacturing*.

Case Study 5:

A Middle East packaging supplier

The challenge

Obeikan Investment Group, a leading Saudi supplier of food and beverage packaging to the Middle East, Europe and Africa, realised in 2015 that it needed to increase productivity and reduce losses in order to ensure competitiveness and sustainability.

The solution

Obeikan partnered with GE Digital, which gave Obeikan access to GE's Predix IIoT (Industrial Internet of Things) platform and GE's manufacturing software, Asset Performance Management (APM) and Field Service Management Solutions.

Key results

- Use of GE's proprietary Brilliant Manufacturing software suite on Predix to analyse and implement manufacturing productivity opportunities
- Higher machine uptime based on asset-wide maintenance data analysis and use of predictive maintenance enabled by APM
- Creation of open, cloud-based marketplace for industrial apps developed by Obeikan Digital Solutions

Key takeaways

- A successful digital transformation starts with accurate identification of a problem
- The transformation never ends, because digitisation drives continuous improvement and process optimisation

Understanding the future of industrial digitisation

In 2014, the first PwC Industry 4.0 study highlighted how the integration of horizontal and vertical value chains would not only enhance efficiency and innovation, but also affect the way industrial organisations operated. The 2016 PwC survey *Industry 4.0: Building the digital enterprise* identified the key building-block digital technologies and explained why digitisation would transform horizontal and vertical processes within industrial organisations, as well as product design. We also analysed why data is the new currency and why people skills and corporate culture are the key drivers of Digital IQ, which measures an organisation's ability to harness and profit from new technology.³

Our research from that time, which was supported and validated in 2018–19 by the eight case study examples, drew on key insights about the early stages of digitisation summarised below:

- Digital skills and processes must be embedded throughout an organisation and not isolated in centralised or specialised groups.
- A range of corporate and shop-floor jobs will increasingly require IT and OT skills.
- The shortage of these emerging skills means that organisations that invest in digital training of their workforce will enjoy a competitive advantage.
- The convergence of IT and OT is changing corporate governance and driving organisations to restructure.
- More frequent development and sharing of apps across functions such as maintenance, operations and IT creates synergies and encourages further integration.

Our analysis of the latest case studies in this paper highlights two additional developments:

First, increasing horizontal and vertical integration, driven by digitisation, will in turn require several key operational changes. These relate to the management of internal functions such as product and process design and engineering; then, to end-to-end procurement, supply chain, distribution and after-sales; and finally, to the availability of data paired with advanced planning tools and further enabled by digital twinning to integrate and optimise all operational functions.

Second, digitisation increasingly adds value for customers through improved delivery of products and services or by using data and software to develop a new business model, as shown in Case Studies 6 and 7.

Case Study 6:

A site maintenance and manufacturing provider

The challenge

A large multinational company that offers site management and manufacturing services to chemical factories in Europe realised that it could add value for customers by increasing uptime at sites and improving safety. Achieving this goal required a shift towards predictive maintenance services, which increased the efficient use of machinery while reducing maintenance staff.

The solution

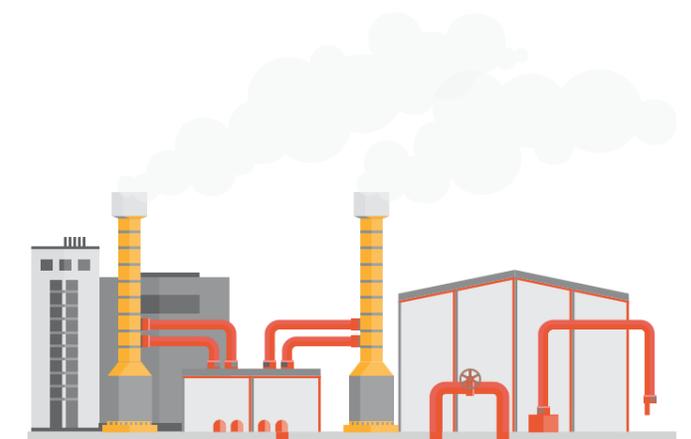
Seven scalable pilot projects were conducted to demonstrate significant safety and uptime improvements, with corresponding cost savings. These projects were then expanded as a general customer offering, along with further solutions.

Key results

- Scaling up of pilot projects to thousands of assets with expected savings of hundreds of millions of dollars
- A subsequent software solution that allows customers to search through libraries of predictive maintenance models suitable for their assets
- Hiring of maintenance experts with data and modelling skills, along with software architects

Key takeaways

- A clear business case and stakeholder buy-in are essential
- Predictive maintenance has significant potential to increase safety, reliability, energy efficiency and uptime
- Automated data collection using sensors and IoT devices is critical, coupled with data analytics and modelling
- Organisations need to hire experts with the requisite skills



³ PwC's Global Industry 4.0 Survey, 2016. *Industry 4.0: Building the digital enterprise*.

Case Study 7:

An Indian bearings manufacturer

The challenge

C-suite executives at one of India's largest roller bearings manufacturers identified the need to improve cost efficiency, productivity and agility in response to an increasing cost focus among their customer base, particularly in the automotive industry.

The solution

After a comprehensive assessment, executives identified digital initiatives to pursue, such as an energy management system, a connected/integrated MES, predictive maintenance and the development of smart products and services for the long term (for example, the use of sensors on railway bearings to measure bearing health and identify potential failures).

Key results

- A business case was prepared with a projected payback period of three to five years. A detailed implementation road map was then put in place using proof-of-concept and piloting approaches
- The skills and capabilities of existing staff were built up, and the company hired new people with data analysis capabilities while also addressing the data security concerns of customers

Key takeaways

- Market pressures caused an urgent need to respond and enhance performance
- Digitisation was driven by the company's most senior executives
- The use of pilot projects helped manage implementation risk and make the business case for scaling up initiatives
- The change was an opportunity to build up the skills of existing staff, as well as bring in essential capabilities

The eight case studies in this report make clear how far the role of digital technology goes beyond traditional IT systems. It also encompasses OT and data and analytics technologies. Full integration and linkage among these different technologies, and the ecosystems they are part of, are essential to a successful digital transformation (see Figure 5). Yet success is impossible without a digitally smart workforce that is familiar with Industry 4.0 skills and tools.

Fig. 5: Four interrelated systems form the basis of the digital manufacturing ecosystems of the future



Source: PwC's Global Digital Operations Study, 2018. *Digital Champions*.

These challenges are the subject of the second part of the report *Digital Champions: How industry leaders build integrated operations ecosystems to deliver end-to-end customer solutions*, which will be published in January 2020. The report will elaborate further on the emerging theory of digital manufacturing and operations, in which successful, digitised industrial organisations will increasingly have to act like software companies in response to four key factors:

- The **connected customer** seeks a batch size of one, necessitating greater customisation of products and delivery time, improved customer experience, use of online channels and outcome-based business models.
- **Digital operations** require both engineering and software abilities to enable extensive data analysis and IoT-based integration, as well as digitisation of products and services.
- Organisations need **augmented automation**, in which machines become part of the organisation via closely connected machine-worker tasks and integrated IT and OT.
- **Future employees** will be 'system-savvy craftspeople' with the skills to use sensors in order to collect and analyse accurate data, as well as design and manage connected processes.

Case Study 8:

A US cutting-tool manufacturer

The challenge

The CEO of a US-based cutting-tool manufacturer recognised the need to boost productivity and reduce costs in order to remain competitive.

The solution

Existing products, processes and skill levels were assessed and customer inputs gathered. This initial assessment concluded that production machinery was outdated and in particular did not adequately capture and integrate data. The company targeted operational improvements for quality and tool management using enterprise resource planning (ERP). Experts with data and software skills were hired to help design a new standard IT architecture and digital operations road map.

Key results

- A core network system with in-built CAD/CAM integration, tool management and scheduling software
- Linkage to the MES platform, with the added ability to distribute software updates to all machines where needed
- Dashboards at the machine, supervisory and management levels
- Eventual creation of a cloud-based database of operations to enable ongoing performance tracking

Key takeaways

- Manufacturers need to be competent in core operations and capabilities such as lean manufacturing and MES before leapfrogging into digital initiatives.
- Digital transformations require new data and technology skills that were not available within the organisation.
- Customer-facing digitisation calls for significant internal digitisation as a prerequisite.

Conclusion: Successful digitisation — a four-point agenda for CEOs

Responding to the significant changes demanded by digitisation requires leadership and accountability from the top in four distinct areas.



CEOs will need to drive organisational changes that address new digital capabilities and streamlined digitised processes. The Japanese auto supplier and the Indian bearings manufacturer are particularly relevant case studies in this respect.



CEOs must overhaul recruitment to ensure more hiring of software and IoT engineers and data scientists. Meanwhile, existing employees must receive the right training to become a digitally smart workforce, capable of using the new technologies. The German chemicals company, the European maintenance-services company and Obeikan offer instructive illustrations of how an organisation can expand and integrate such skills.



Industrial companies will need to acquire more of the attributes of software businesses, with the ability to develop use cases quickly and turn them into software products. The European maintenance company and Obeikan have both successfully accomplished this transition.



Technology investments that enable digitisation must extend beyond IT to include significant OT such as track-and-trace solutions, asset management and digital twinning. The CEO with an overview of both technology and operations is best placed to drive these investments, rather than a traditional CIO. Among our case studies, the MENA aerospace supplier and the European oil and gas company demonstrate the need for this broad strategic vision in leading the digital change.

On their own, none of these initiatives is sufficient to achieve the successful digitisation of a manufacturing organisation. Yet in combination they form an indispensable agenda for CEOs aiming to lead companies that are digital champions.

Methodology

As part of the 2018 Global Digital Operations Study, 1,155 manufacturing executives were interviewed in 26 countries, primarily about their attempts to implement Industry 4.0 and the progress they were making in three main areas: ecosystems, new technologies and digital cultures. From these interviews, four categories were created that represent different stages of digital maturity, with 'digital champions' at the leading edge of their industries:

- 1. Digital novice:** The company employs some isolated digital solutions and applications, but these exist at the functional or department level within the organisation.
- 2. Digital follower:** Internal functions such as sales, manufacturing, sourcing and engineering are integrated and collaborate closely. But there is little activity beyond vertical digital integration within the company. The culture and workforce at these companies are not yet digitally oriented.
- 3. Digital innovator:** The enterprise is digitally connected to external partners and customers, using integrated platforms for information exchange and collaboration. But horizontal digitisation is limited to the immediate supply chain, with no wider ecosystem for customer solutions, technology or people. Digital innovators prize digitisation and encourage the workforce to help identify new digital solutions, but their advances are limited in scope.
- 4. Digital champion:** The enterprise has a clear strategic position in the marketplace, with complex and tailored customer solutions, offered via multilevel customer interactions. These companies have implemented near-real-time end-to-end integration and connectivity of their value chain across internal and external networks. They know how to leverage technology to connect customers, partners, operations and people to create value through ecosystems in new ways. Digital champions have built a digital culture by establishing new methods of working and making substantial investments in training, sourcing and developing new capabilities and skills.⁴

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⁴ PwC's Global Industry 4.0 Survey, 2016. *Industry 4.0: Building the digital enterprise.*

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Steve Pillsbury is a principal with PwC US and the US lead for PwC's Digital Operations Impact Center. He helps manufacturers define and execute strategies to modernise their operations through digital/IIoT enablement, including digital factories, connected supply chains, new manufacturing methods, connected field services and the full digitisation of product development. Pillsbury has worked with IIoT sellers to help them develop innovations that address the outcomes sought by manufacturers and has worked with IIoT buyers to help them define the art of the possible and incorporate digital capabilities into their operations.

About the Global Manufacturing and Industrialisation Summit (GMIS)

The Global Manufacturing and Industrialisation Summit (GMIS) was established in 2015 to build bridges between manufacturers, governments and NGOs, technologists, and investors so that they can harness the transformative power of the Fourth Industrial Revolution. A joint initiative by the United Arab Emirates and the United Nations Industrial Development Organization (UNIDO), GMIS is a global platform that presents stakeholders with an opportunity to shape the future of the manufacturing sector and contribute towards global good by advancing some of the United Nations' Sustainable Development Goals.

The first two editions of the Global Manufacturing and Industrialisation Summit were held in Abu Dhabi, United Arab Emirates, in March 2017, and Yekaterinburg, Russia, in July 2019, respectively, with each edition welcoming more than 3,000 high-level delegates from more than 40 countries.

GMIS 2020, the third edition of the Global Manufacturing and Industrialisation Summit, will be held alongside Hannover Messe, the world's largest industrial trade fair, between 20 and 21 April 2020 in Hannover, Germany, and will focus on globalisation in pursuit of inclusive and sustainable global value chains.

You can find more about GMIS at:

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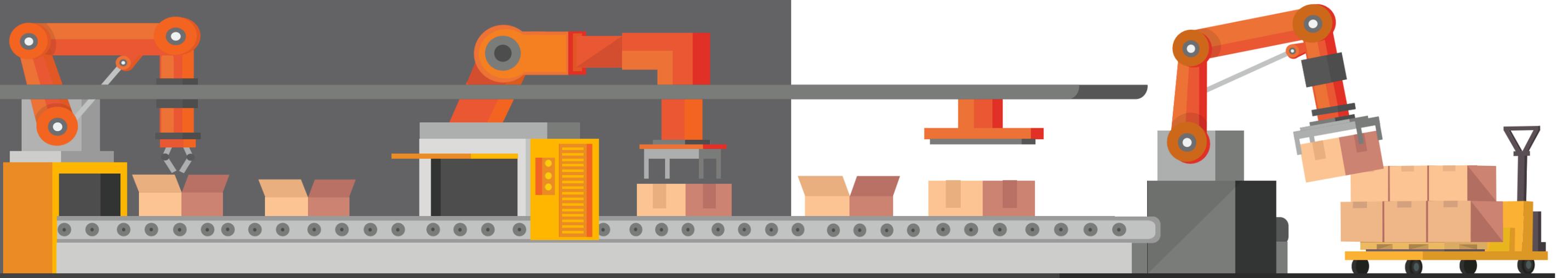
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