

Smart factories @ scale

Seizing the trillion-dollar prize through efficiency
by design and closed-loop operations



Executive summary

Beyond labor productivity and asset-efficiency, the next performance leap in factories will be through end-to-end effectiveness of production systems:

- **Efficiency by design:** virtual design, simulation, and commissioning of factories before entering into physical operations to make processes more efficient throughout their life cycle.
- **Effectiveness in operations:** leveraging data and advanced analytics to reach “closed-loop” and ultimately self-optimizing operations.
- **Deployment at scale:** moving from an initial pilot to systematic deployment to realize the full value of smart factories.

With these issues shaping the future of manufacturing, the next challenge for organizations lies in scaling their smart factory initiatives. The key takeaways from our research include:

Organizations are showing an increasing appetite and aptitude for smart factories:

- Compared to two years ago, more organizations are progressing with their smart factory initiatives today and one-third of factories have already been transformed into smart facilities.
- They plan to make 40% more smart factories in the next five years and increase their annual investments by 1.7 times compared to the last three years.
- Organizations are focusing on both efficiency by design and achieving operational excellence through closed-loop operations.

The potential value add from smart factories is bigger than ever:

- The size of the smart factory prize is \$2 trillion on average, higher than our 2017 estimate. Two-thirds of this overall value is still to be realized: efficiency by design and closed-loop operations will make equal contributions.

- There are a number of reasons for this uptick: higher penetration of smart factory initiatives, aggressive plans by organizations, and an increase in expected benefits. These benefits could be seen not just in productivity improvements but also in accelerated product-portfolio rotation and faster time to market which will further translate into an increased market share.
- 5G is set to become a key enabler of smart factory initiatives as its features would provide manufacturers the opportunity to introduce or enhance a variety of real-time and highly reliable applications.

Organizations need to confront the next challenge – scaling smart factory initiatives:

- Organizations realize that success is hard to come by, with just 14% characterizing their existing initiatives as successful.
- The main issues with achieving scale are challenges with IT-OT convergence and the need to develop “hybrid” capabilities and soft skills.
 - To ensure digital continuity¹ and enable collaboration, effective IT-OT convergence will be critical, including digital platform deployment and integration, data readiness, and cybersecurity. Agnostic and secure multilayer architectures will allow a progressive convergence.

PLM², MES/SCADA,³ and robotics remain key components of industrial architectures. However, the main areas of investment for at-scale deployments are IoT and manufacturing intelligence, which support data-driven operations as well as remote and mobile capabilities.

Fewer than 50% of organizations have the adequate data availability and cybersecurity measures in place, while nearly a quarter of manufacturers have experienced a cyber-attack in the last year.

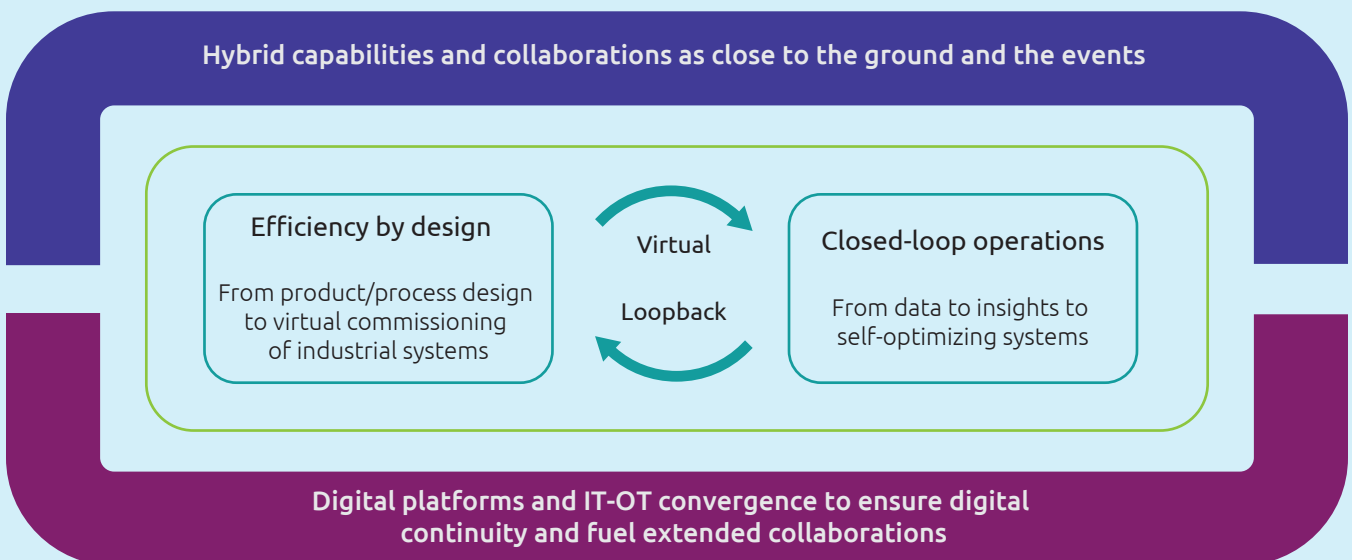
- In addition to digital talent, a range of skills and capabilities will be required to drive smart factory transformation. These include hybrid profiles, such as “engineering–manufacturing”, “manufacturing–maintenance” and “safety–security”. Soft skills, such as problem solving and collaborative skills, will also be critical. Nevertheless, organizations are not investing fast enough to fill the skill gaps.
- In parallel, to unlock the promise of the smart factory, organizations need to design and implement a strong governance program and develop a culture of data-driven operations.

Organizations need to learn from high performers:

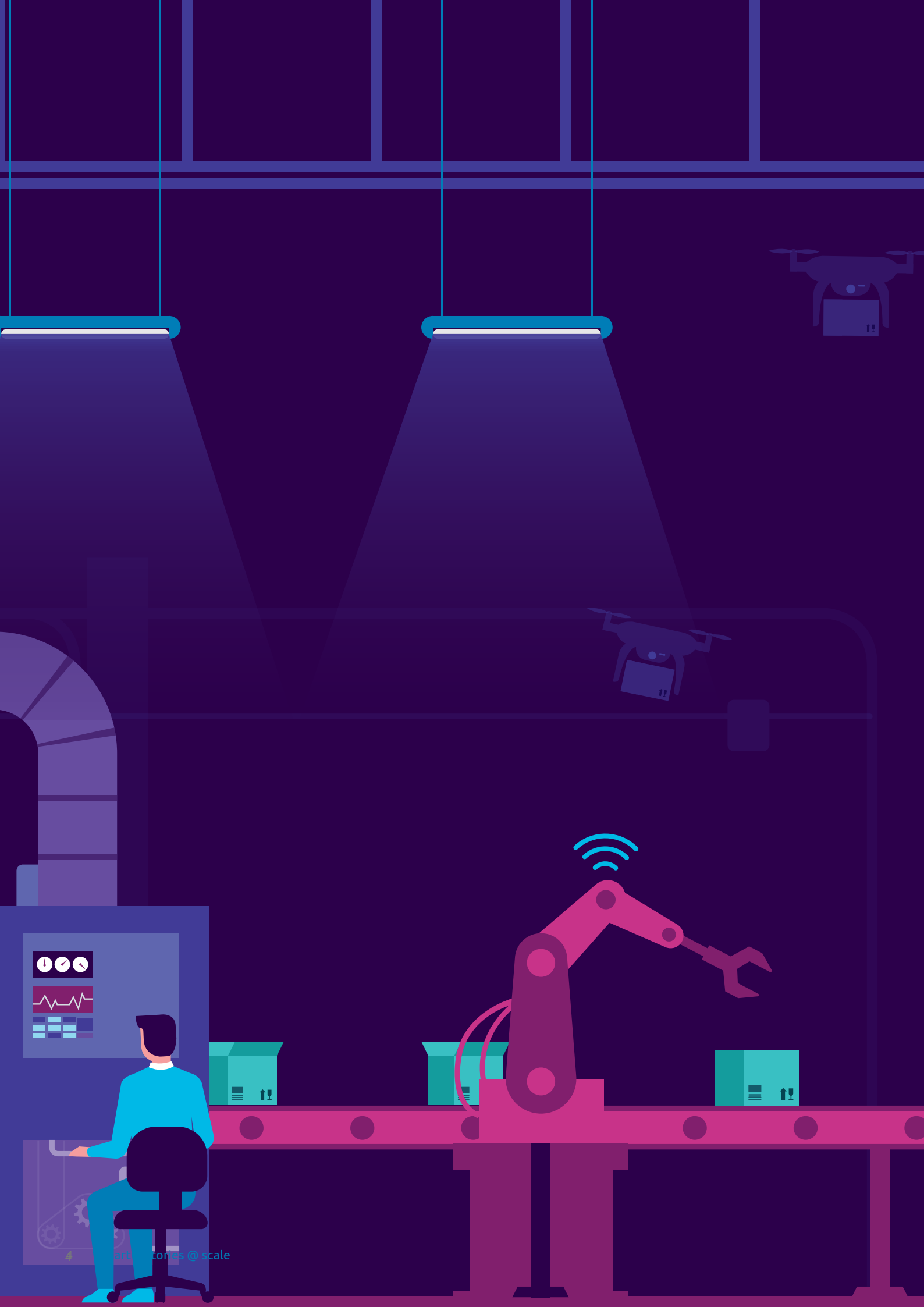
- A small group of high performers – which we call the “front runners” (10% of the sample) – have successfully digitalized their industrial system. This elite group of companies make significant investments in the foundations (digital platforms, IT-OT convergence, talent, governance), and balance “efficiency by design” and “effectiveness in operations,” leveraging the power of data and collaboration (refer to Figure 1).
- Organizations should identify where they are lagging behind and learn from the best practices of the front runners.

Smart factories are a critical part of the Intelligent Industry. Therefore, realizing the complete potential of smart factories, will be the key to reaping the benefits of intelligent industry.

Figure 1. The smart factory challenge at a glance



Source: Capgemini analysis.





Introduction

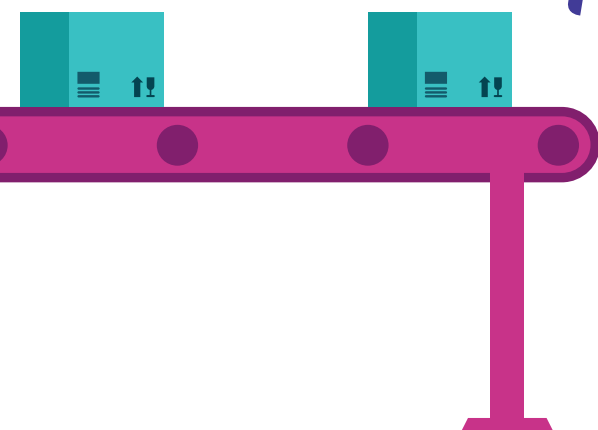
Manufacturers are committing significant investments towards smart factories. The smart factory market for technologies such as MES, ERP, PLM, and others is estimated to be worth approximately \$154 billion in 2019, growing at a CAGR of close to 10% during 2019–2024.⁴ The market for smart manufacturing platforms alone stands at \$4.4bn in 2019 and is expected to grow at a CAGR of 20% over the next five years.⁵

This growth confirms a trajectory that we saw when we researched this subject back in 2017. That research showed that close to 45% of manufacturers had a smart factory initiative underway.⁶

Today, we wanted to see how manufacturers are faring on the smart factory journey. We surveyed 1,000 manufacturers, focusing primarily on organizations that had a smart factory initiative underway. We also conducted nearly twenty in-depth discussions with executives overseeing a smart factory initiative or a smart factory. Our aim was to understand the progress of initiatives, the adoption of digital technologies, and the challenges faced by manufacturers in achieving scale. Overall, we found that while manufacturers are committing significant investments, many are struggling to realize the enormous potential offered by smart factories.

This report, that is part of our series on the 'Intelligent Industry',^{7,8} looks at the following areas:

1. Organizations' appetite for smart factories and how their initiatives are progressing so far
2. The size of the smart factory prize
3. The challenges organizations face in scaling their initiatives
4. The lessons to be learned from high-performing organizations that are far ahead in their smart factory transformation journey
5. Recommendations to accelerate smart factory transformation.



What is a smart factory?

“Smart” factories leverage digital technologies to gain significant improvements in productivity, quality, flexibility, and service.

Three key digital technologies enable the smart factory:

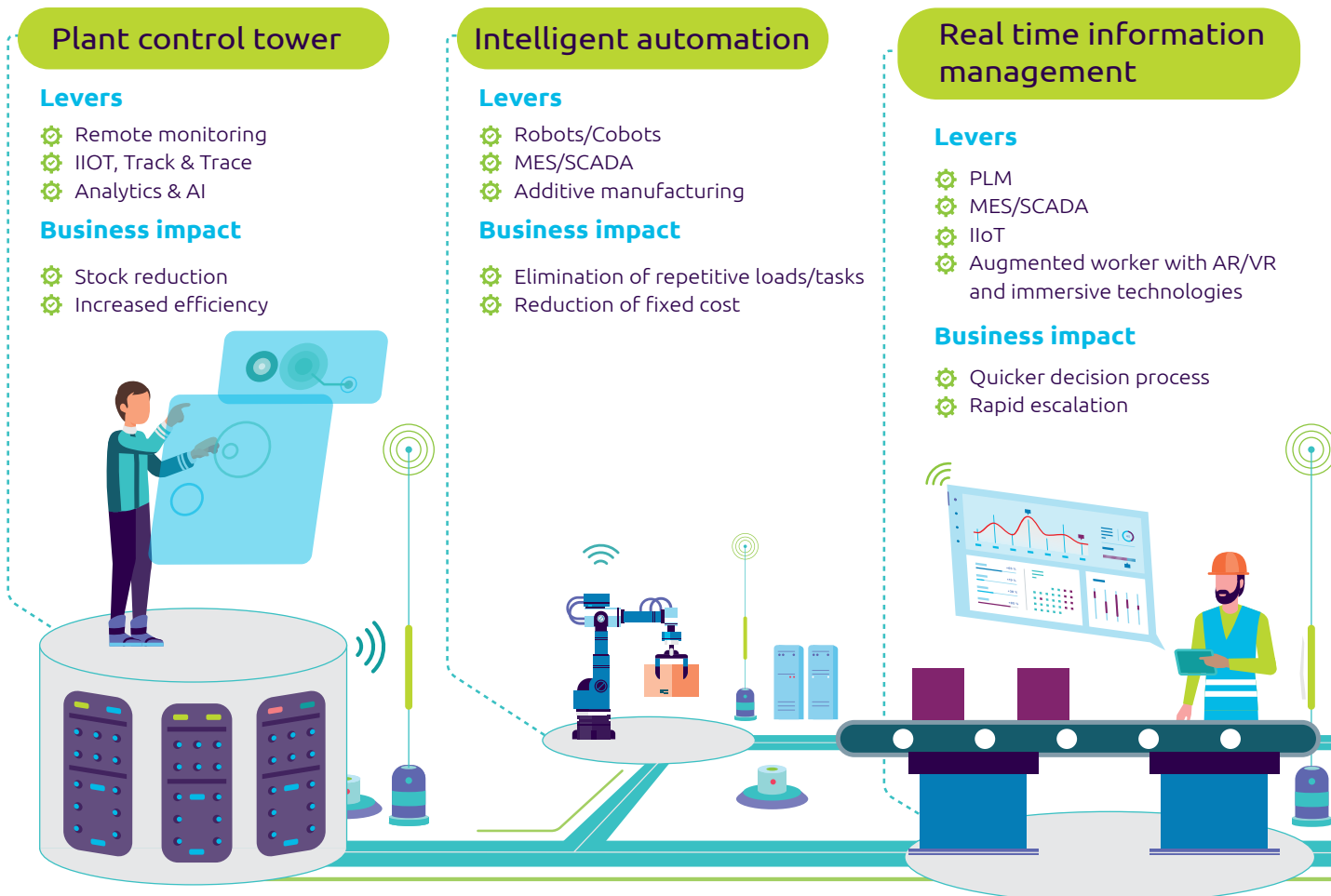
- connectivity (leveraging Industrial IoT to collect data from existing equipment and new sensors)
- intelligent automation (e.g., advanced robotics, machine vision, distributed control, drones).
- cloud-scale data management and analytics (e.g., implementing predictive analytics/AI)

These digital technologies will also enable IT-OT convergence to support end-to-end digital continuity from design to operations (digital twin).

The main characteristic of a smart factory is “closed-loop,” data-driven optimization of end-to-end operations. Advanced analytics are first used for decision support, but the ultimate goal is to reach “self-optimizing operations” where the factory constantly adapts to demand, variations in supply and process deviations.

Figure 2 shows how various technologies are deployed to improve the performance of core and support operations.

Figure 2. Smart factory operations leveraging digital technologies



Energy management

Levers

- ⚙️ Smart energy management leveraging sensors and IIoT
- ⚙️ Analytics and AI (prescriptive & predictive)

Business impact

- ⚙️ Energy savings
- ⚙️ Reduction of peak consumption

Enhanced operator

Levers

- ⚙️ Augmented worker with AR/VR and immersive technologies
- ⚙️ Remote assistance

Business impact

- ⚙️ Quality improvement
- ⚙️ Increased efficiency
- ⚙️ Operator empowerment

Quality analytics and Adaptive testing

Levers

- ⚙️ Analytics and AI

Business impact

- ⚙️ Improving efficiency
- ⚙️ scrap reduction

Predictive maintenance

Levers

- ⚙️ Analytics and AI
- ⚙️ IIoT
- ⚙️ Predictive analytics

Business impact

- ⚙️ OEE, MTTR, MTBF improvement
- ⚙️ Minimize downtime

Flow simulation

Levers

- ⚙️ Digital twins
- ⚙️ IIoT
- ⚙️ Simulation with AR/VR

Business impact

- ⚙️ Line balancing
- ⚙️ Virtual commissioning
- ⚙️ Reduction of production risk



Source: Capgemini Invent and Capgemini Research Institute.

1. Manufacturers are investing heavily in smart factories

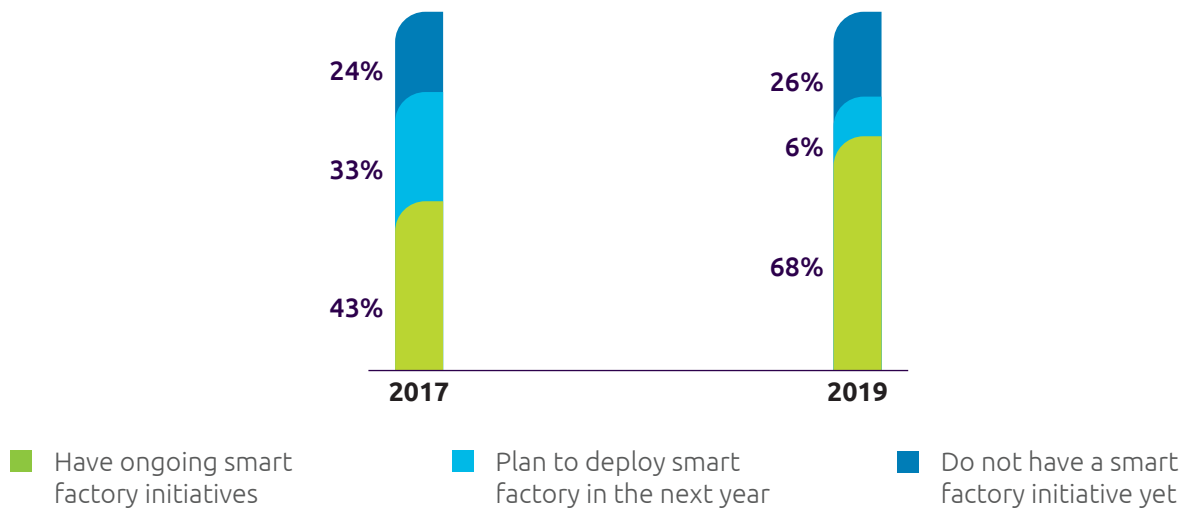
Nearly 70% of manufacturers are pursuing smart factory initiatives

The number of organizations with ongoing smart factory initiatives has increased significantly since our last report on this subject in 2017. In that report, we found that 43% of organizations had ongoing smart factory projects. In 2019, this climbs to 68%.

As Figure 3 shows, a more detailed comparison with 2017 reveals that most of the organizations that were planning smart factory initiatives two years ago (33%) have now

launched them. Take-up is fuelled by manufacturers' excitement about the potential of these initiatives. *"There are three primary reasons why we took up the smart factory initiative,"* explains Dr. Seshu Bhagavatula, President, New Technologies and Business Initiatives, Ashok Leyland, one of the largest heavy vehicle manufacturers in India.⁹ *"The first is to improve the productivity of our old factories through modernizing and digitizing their operations. The second is to deal with the quality issues that are difficult for human beings to detect. And the third is to incorporate made-to-order or mass-customization capabilities."*

Figure 3. Smart factory adoption comparison – 2017 vs 2019



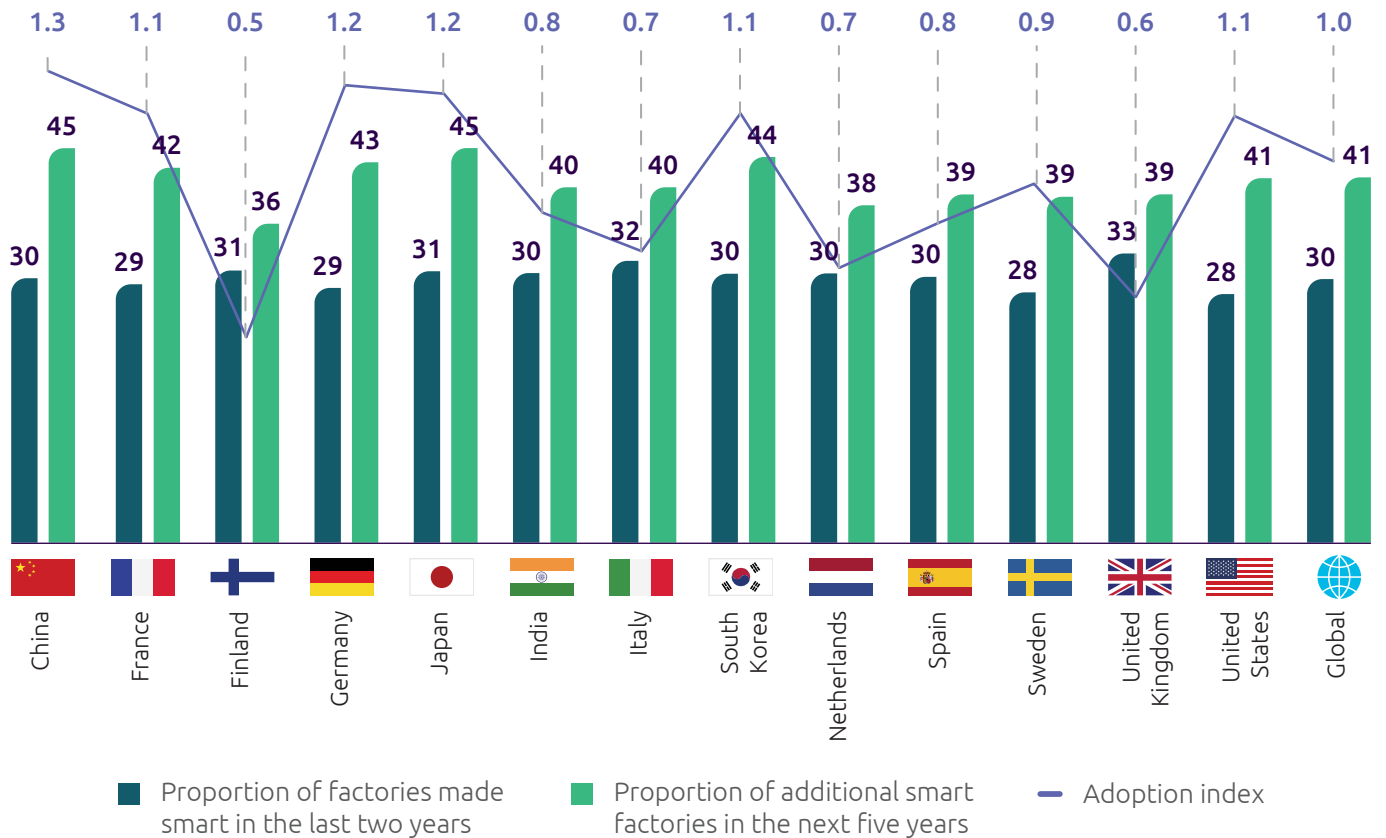
Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=1348 manufacturers.

Organizations have, on average, made 30% of their factories smart. In order to understand and measure the ambition of plans for the future, we developed a smart factory adoption index. If a country or a sector achieves a score greater than 1, it signifies a more aggressive expansion plan than

the average. China, Germany, and Japan are the top three countries in the smart factory adoption, closely followed by South Korea, the United States, and France.

Figure 4.

Percentage of factories that were transformed into “smart” operations in the last two years and future expansion plans, by country



* The smart factory adoption index shows the future expansion plans. An index greater than one means that the country has a more aggressive expansion plan in the future compared to the average and vice-versa.
 Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=912 manufacturers.



There are three primary reasons why we took up the smart factory initiative. The first is to improve the productivity of our old factories through modernizing and digitizing their operations. The second is to deal with the quality issues that are difficult for human beings to detect. And the third is to incorporate made-to-order or mass-customization capabilities."

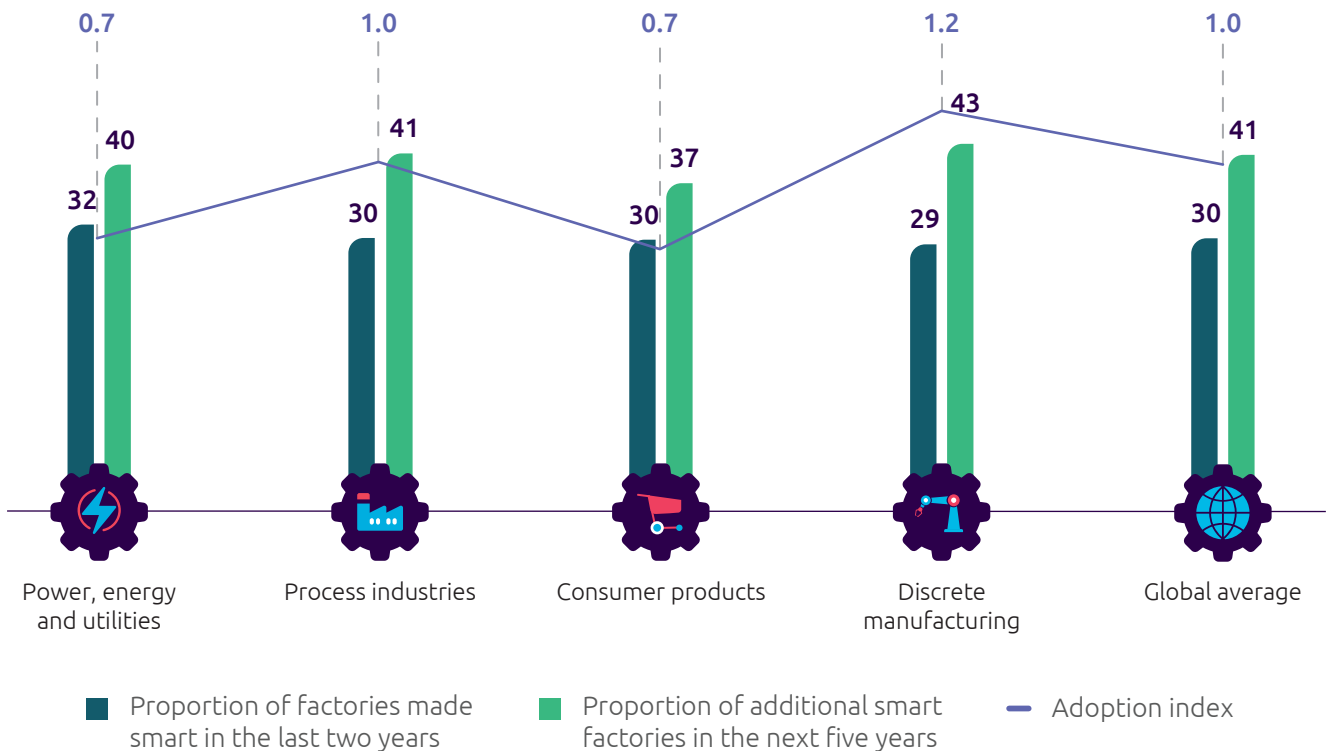
- Dr. Seshu Bhagavatula,
 President, New Technologies and Business Initiatives,
Ashok Leyland.

Organizations have already made one-third of their factories smart, and plan to transform 40% more over the next five years

Not only have more organizations kicked off a smart factory initiative, they also have ambitious plans for their overall factory footprint.

As Figure 5 shows, the power, energy, and utilities sector has made slightly better progress than the others so far. While discrete manufacturing lags behind its peers in adoption to date, its score of 1.2 shows that it has aggressive plans to catch up.

Figure 5. Percentage of factories that were transformed into “smart” operations in the last two years and future expansion plans, by sector



* The smart factory adoption index shows the future expansion plans. An index greater than one means that the sector has a more aggressive expansion plan in the future compared to the average and vice-versa.

Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=912 manufacturers.

On average, organizations aim to upgrade 41% more factories in the next five years. Our research shows that a number of sub-sectors have ambitious plans that make a strong contribution to this rapid expansion, including:

- automotive
- aerospace
- medical devices
- semiconductor/high-tech.

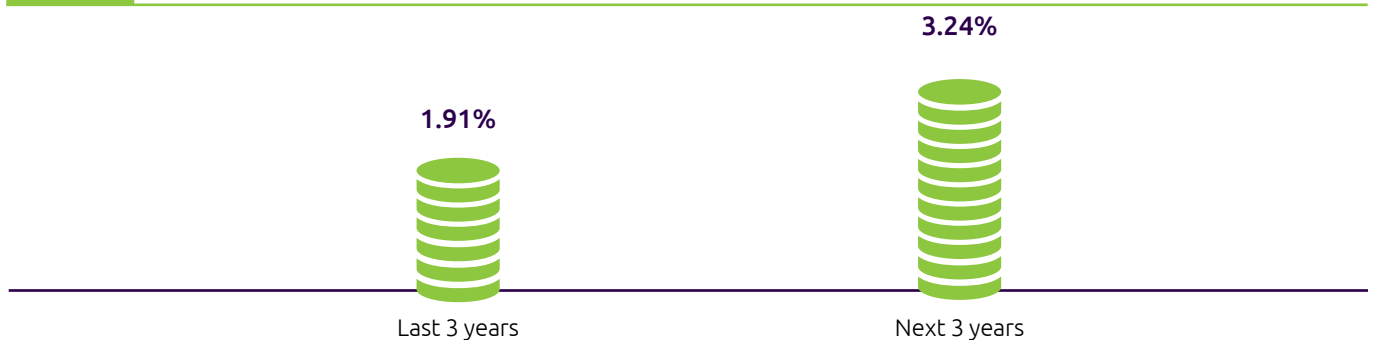


Manufacturers plan to increase their annual investments in smart factories by a factor of 1.7

The enthusiasm for smart factories is also evident from organizations' investment plans. Our research shows that, on

average, organizations are planning to invest, on an annual basis, 3.24% of their revenue for the next three years. This is 1.7 times more than the amount annually invested for last three years (see Figure 6).

Figure 6. Average annual investments in smart factories as a percentage of revenue: last three years vs next three years



Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=912 manufacturers.

Such significant investment plans are primarily driven by greenfield projects:

- Over half of all organizations (55%) said their smart factory initiatives include greenfield projects.
- Greenfield projects are particularly prevalent among small and mid-sized companies (those with annual revenues below \$10 billion). For example, in the \$5 billion to \$10 billion revenue bracket, greenfield projects represent 59% of initiatives in 2019, up from 50% in 2017.

While greenfield projects present opportunities to implement new architecture or concepts and allow

experimentation at scale, they also need higher investments, often to the tunes of hundreds of millions of dollars.

This is because the investments include the costs of land, construction, electrification, and machinery, as well as the software and hardware required for the smart factory. For example, P&G's greenfield smart factory in Cincinnati, spans across 485 acres and will cost \$500 million.¹⁰ Similarly, Audi invested more than \$1 billion for their greenfield smart factory in San Jose Chiapa plant in Mexico.¹¹ In percentage terms, greenfield smart factory initiatives are going to take up a significant share of revenues, especially in the small to mid-size bracket.

Though organizations consider efficiency by design a critical aspect, their journey is just beginning

A factory is increasingly a very complex and living system that must be first efficient by design, for both greenfield and brownfield projects. Therefore, before organizations create physical operations, they have to commission, design, and simulate a factory using virtual technologies. This is to ensure processes operate at maximum efficiency. Toyota, for instance, has taken a significant step in this direction. Its design engineering and production engineering division simulate the component design and assembly process in

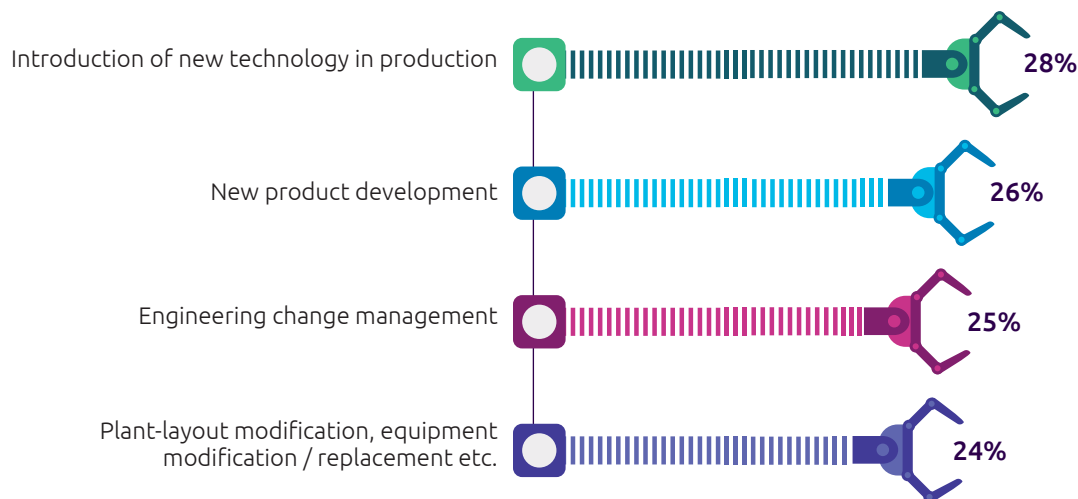
the virtual space before the actual production for a model starts.¹²

Our research shows that nearly half of organizations (47%) consider efficiency by design to be a critical aspect of their initiatives. To assess organizations' journey to efficiency by design, we have considered three key areas:

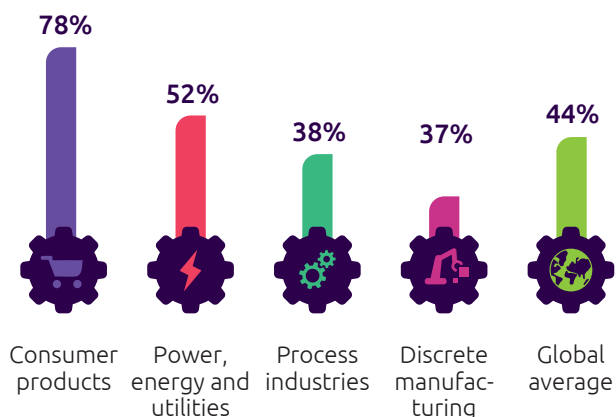
- Virtual simulation of production lines – 30% say production lines are simulated before manufacturing begins
- Concurrent product-process design – 44% are using this approach
- Virtual commissioning of industrial systems – 40% of industrial systems are virtually commissioned.

Figure 7. Organizations' journey to efficiency by design

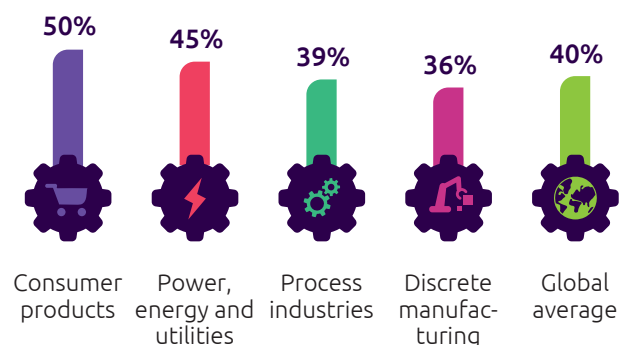
Proportion of cases in which organizations simulate their production line before the actual manufacturing



Proportion of organizations that concurrently design their product and industrial processes



Average percentage of industrial systems that are virtually commissioned



Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=1,000 manufacturers.

Organizations have been making progress in their operational excellence journey, though they still have a long way to go

Over a third of organizations (37%) consider that improving industrial system efficiency is the next frontier in improving factory performance, rather than improving labor productivity. Groupe PSA, for example, plans to bring down the cost of each vehicle by 700€ by leveraging data and digitally optimized processes, as part of their “excellent plant” program.¹³

We have explored four key areas to assess organizations’ maturity in operational excellence:

- Adoption of data-driven decision making
- Evolution from reactive to preventive and predictive decision making

- Digital process optimization
- Preparedness to deal with bottlenecks and unplanned production issues.

Our analysis shows that organizations have been making progress:

- Close to a third have attained maturity in data-driven and predictive decision making as well as optimizing their processes digitally.
- We also found that around 40% are prepared to deal with bottlenecks and unplanned production issues.

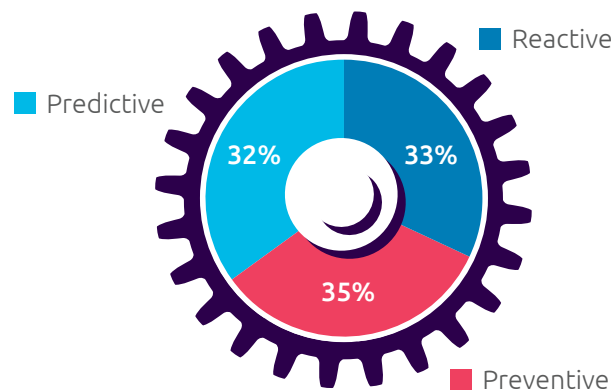
While most organizations are yet to achieve maturity in the four areas, companies have been making encouraging progress.

Figure 8. Organizations’ journey to attain operational excellence

To what extent has your organization adopted data-driven decision-making in the following areas?



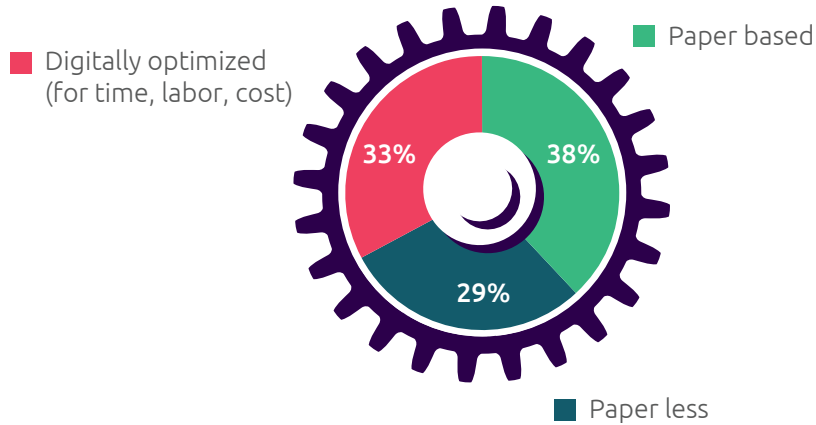
Approach to managing production decisions



Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=1,000 manufacturers.

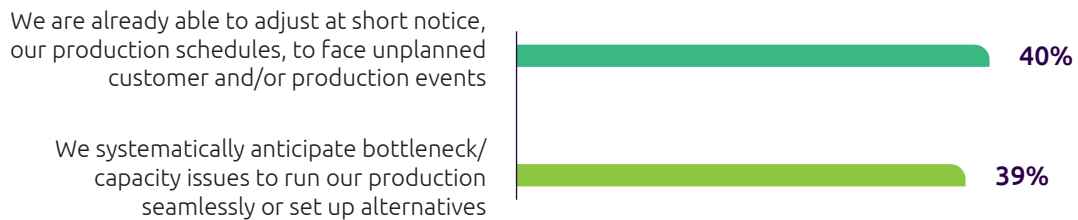
Figure 8. Organizations' journey to attain operational excellence (continued)

Current mix of processes



Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=912 manufacturers.

Preparedness to anticipate bottleneck issues and dealing with unplanned production events



Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=1,000 manufacturers.

33%

The share of production processes that are digitally optimized on average at a manufacturing organization

Efficiency by design and closed-loop operations drive smart factory benefits equally

In our research, we categorized the gains from smart factory into two broad areas:

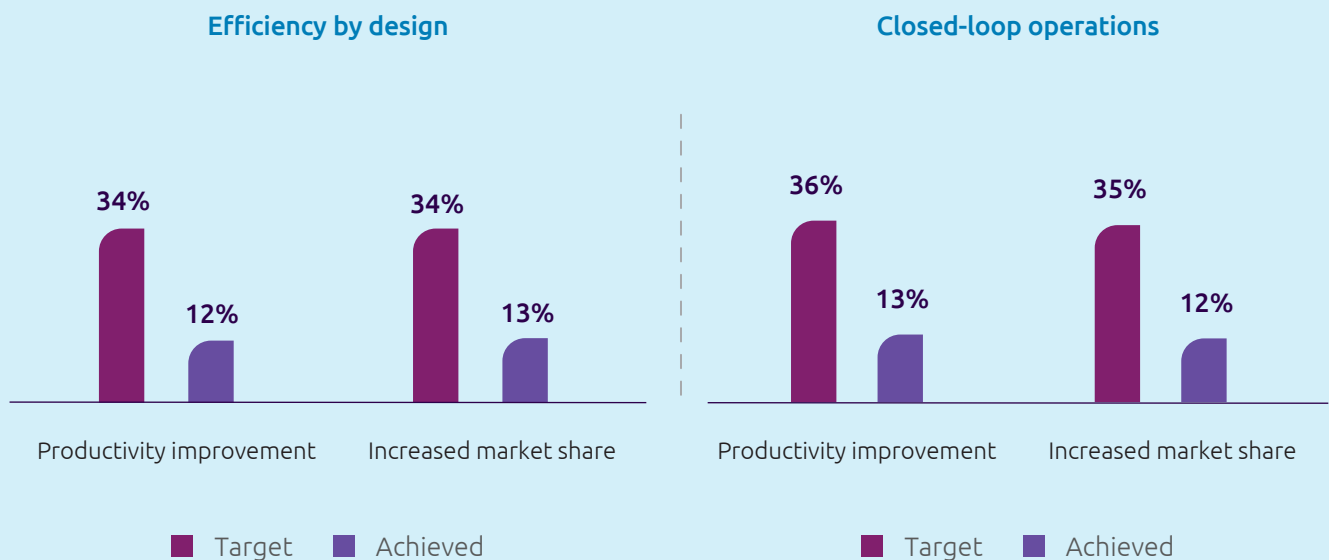
- Productivity improvement, which deals with the cost-effectiveness of production
- Increased market share, which drives the topline for manufacturers.

Organizations can leverage smart factory initiatives to minimize the costs of goods produced by optimizing areas such as asset utilization, cost for defects, cost for maintenance and avoiding unplanned downtimes. All such factors that minimize the costs of goods produced contribute to productivity gains.

At the same time, smart factory initiatives will also help organizations to improve product-portfolio rotation, time to market and on-time delivery. Improvements in such areas will translate into increased market share as they will help organizations capture market opportunities faster and better than their average competitors.

Our survey data shows that efficiency by design and closed-loop operations will contribute equally on both fronts (see Figure 9). Both these will impact KPIs such as Overall Equipment Effectiveness (OEE), maintenance costs, labor costs, time-to-market, on-time delivery among others, thereby driving the productivity and market share.

Figure 9. Efficiency by design and closed-loop operations are driving smart factory gains at the same rate



Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=912 manufacturers.

Efficiency by design can contribute to productivity gains by helping in areas such as asset utilization and cost for defects. It will also make a positive impact on areas such as product-portfolio rotation and time to market which will translate into improved market share.

Similarly, closed-loop operations will help in productivity gains by optimizing such areas as maintenance costs, inventory cost, and asset utilization. In parallel, it will also help in reducing time to market, improving on-time delivery, and enhancing product quality thereby increasing market share.

2. The size of the smart factory prize is bigger today than it was in 2017

Smart factories can help manufacturers drive their productivity gains. In 2017, we estimated that the productivity gains from smart factory initiatives could add anywhere between \$0.5 trillion to \$1.5 trillion to the global economy.

To arrive at the value for 2019, we looked at the target productivity gain expected from each smart factory, coupled with the current gains from existing initiatives. In our analysis, we found that manufacturers expect both efficiency by design and operational excellence will contribute equally to this productivity gain. We then used the current value-add contribution that manufacturing makes to global GDP. With that approach, we looked at three scenarios – conservative, average, and aggressive – which represent degrees of smart factory adoption over the next five years and the target productivity gains. The results are:

- Conservative scenario: productivity gains will add \$1.5 trillion in added value to global GDP
- Average: \$2 trillion
- Aggressive: \$2.2 trillion.

The key reasons for these higher estimates in 2019 include:

- Greater interest in smart factories – only 43% of organizations had smart factory initiatives in 2017, but in 2019, this rose to 68%
- As we saw earlier, in 2019 organizations are planning to increase the proportion of smart factories in their overall factory network
- Organizations also expect greater benefits from their initiatives in the future, as programs become more stable as “teething” issues are resolved.



Figure 10. Smart factories have the potential to add between \$1.5 trillion to \$2.2 trillion annually, by 2023

	Conservative scenario	Average scenario	Aggressive scenario
A. Share of factories that became smart in 2017–18 (source: survey data)	29.6%	29.8%	31.6%
B. Expected increase in productivity gains by 2023 compared to the productivity gains achieved so far (source: survey data)	15.9%	20.0%	21.7%
C. Share of additional smart factories in next five years (i.e. by 2023) (source: survey data)	37.3%	41.2%	42.7%
D. Productivity gain target in next five years (i.e. by 2023) at factory level due to smart factory initiatives (source: survey data)	27.8%	33.7%	36.5%
E. Overall productivity gain due to smart factory initiatives by 2023 (A*B) + (C*D)	15.0%	19.8%	22.5%
F. Average annual productivity gain due to smart factory initiatives until 2023 (CAGR computation from E)	2.8%	3.7%	4.1%
G. Approx. manufacturing industry value added in the surveyed geographies in 2019 (source: extrapolated from the data available in the United Nations National Accounts Database)	\$9.85 trillion		
H. Expected additional value added by manufacturing industry due to productivity gain in smart factories by 2023 (sum of realized value and capacity gain) (G*E)	Total value added: \$1.47 trillion	Total value added: \$1.95 trillion	Total value added: \$2.21 trillion

Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=1,000 manufacturers, United nations’ database for national accounts, accessed June 2019.

There are two important aspects of this total value added if we consider the growth of the manufacturing industry – realized value and capacity gain.

The manufacturing industry in the geographies we have surveyed has grown at a pace of 2.8% annually between 2007 and 2017, and we estimate that it will continue to do so for the next five years.

The productivity gain in the average scenario (3.7%) and aggressive scenario (4.1%) exceed this 2.8% industry growth rate. As a result the entire productivity gain would not be realized in dollar value gain in these two scenarios. Instead, USD 478.2 billion and USD 740.2 billion will remain as capacity gain or spare capacity for future growth in average and aggressive scenarios, respectively.

5G will very soon accelerate smart factory initiatives

5G can deliver substantial benefits for industrial operations as it promises huge advances in connection speed, density, and latency. 5G is also unique in that it offers “Network Slicing,” allowing the physical spectrum to be split and to be allocated to specific applications.

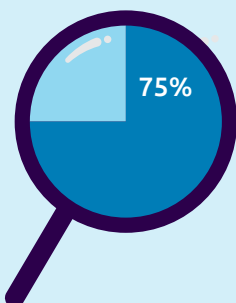
The table below shows a brief comparison of 5G features with previous connectivity solutions and the upcoming WI-FI technology – “Wi-Fi 6”:

	5G	4G (LTE-A)	Wi-Fi 6
Enhanced mobile broadband speed: (peak data rate)	20 Gbps for downlink and 10 Gbps for uplink	1 Gbps for downlink and 500 Mbps for uplink	Approximately 4.8 Gbps
Massive machine type communication: (Number of connected devices per unit area)	1 million/sq.km	100,000 devices/sq.km	Not defined. Depends on the bandwidth required per device
Ultra-reliability and low latency	Network latency is less than or equals to 1 millisecond with 99.999% assurance of delivery	Network latency is 10 milliseconds	Network latency is less than 10 milliseconds for 5Ghz band

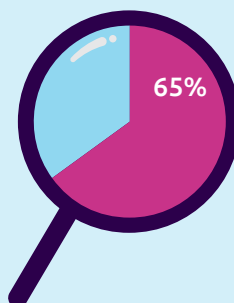
In our recent report on 5G, we found that senior executives believe this technology will be a key enabler in their digital transformation activities (see Figure 11). This is because

it supports a variety of real-time and highly reliable applications.¹⁴

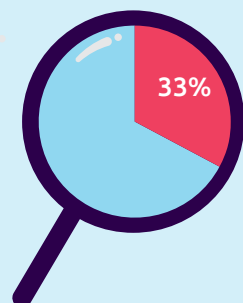
Figure 11. Key findings from our 5G in industrial operations research



Respondents who believe **5G** is a key **enabler** to their **digital transformation**



Respondents who are willing to **implement 5G** for operations **within 2 years of availability**

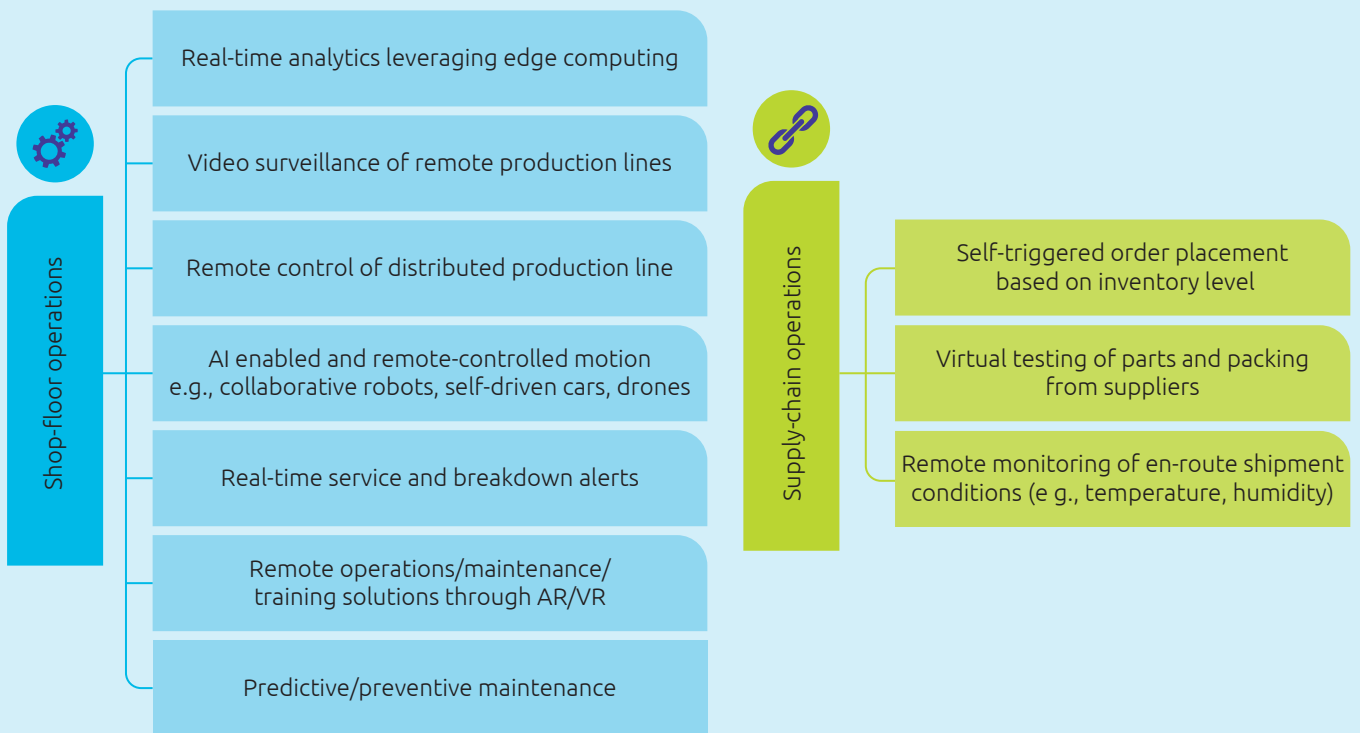


Respondents that have 5G in their connectivity roadmap and **consider applying for a local 5G license**

Source: Capgemini Research Institute, industrial companies’ survey on 5G, March–April 2019, N=806 industrial companies.

The report also identified the most valuable 5G-enabled use cases for shop floor and supply chain areas (see Figure 12).

Figure 12. Critical use cases where 5G adds value



Source: Capgemini Research Institute, industrial companies' survey on 5G, March–April 2019, N=806 industrial companies.

Interest in 5G is so high that some German manufacturers even plan to have their own private 5G networks, removing the need to rely on telecom operators. BASF, the German chemical company, plans to use 5G to further digitize its main production facility in Ludwigshafen, Germany. The plant already has 600,000 networked sensors¹⁵ and other control devices and expects the number of networking elements to increase tenfold in the future. This is a significant factor behind its decision to move to 5G. The company

is also testing automated guided vehicles¹⁶ and believes the necessary video surveillance can only be delivered reliably through 5G. *"In the future, when we use 20 or more vehicles, we'll only manage the massive data transfer with 5G technology,"* explains Matthias Fankhänel, the head of Global Engineering and Maintenance at BASF.¹⁷

3. Scaling smart factories is the next challenge

Organizations recognize the difficulties they are having in reaching scale

Organizations realize that they have a massive task ahead in scaling their smart factory initiatives. Of all the organizations that have smart factory initiatives, nearly 60% say their initiatives are either struggling or that it is too early to comment. Only 14% said they would characterize their smart factory deployments so far as a success. Also, as shown in Figure 9, “achieved” KPIs are significantly lower than the “target” value for the KPIs.

Achieving scale of operations is a significant contributor to this pessimistic view of success. As we showcase later on, so far no technology or platform has been completely adopted

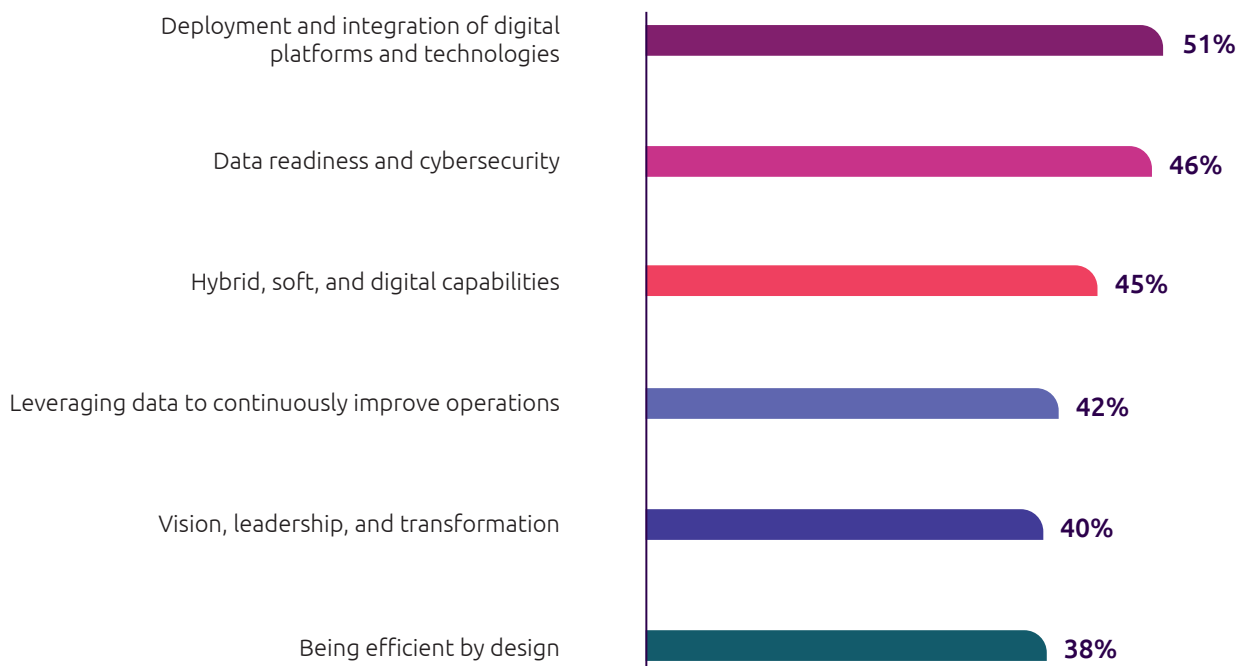
in majority of production lines. *“I think that progress has been slower than we hoped for,”* an executive from a Finnish industrial company told us. *“It has been more difficult. We just haven’t been progressing as well as we would have liked.”*¹⁸

Three major challenges that impede progress

As Figure 13 shows, three major challenges impede the progress of smart factory initiatives:

- deployment and integration of digital platforms and technologies
- data readiness and cybersecurity
- development of hybrid and soft skills.

Figure 13. Major challenges faced by manufacturers in achieving performance at scale



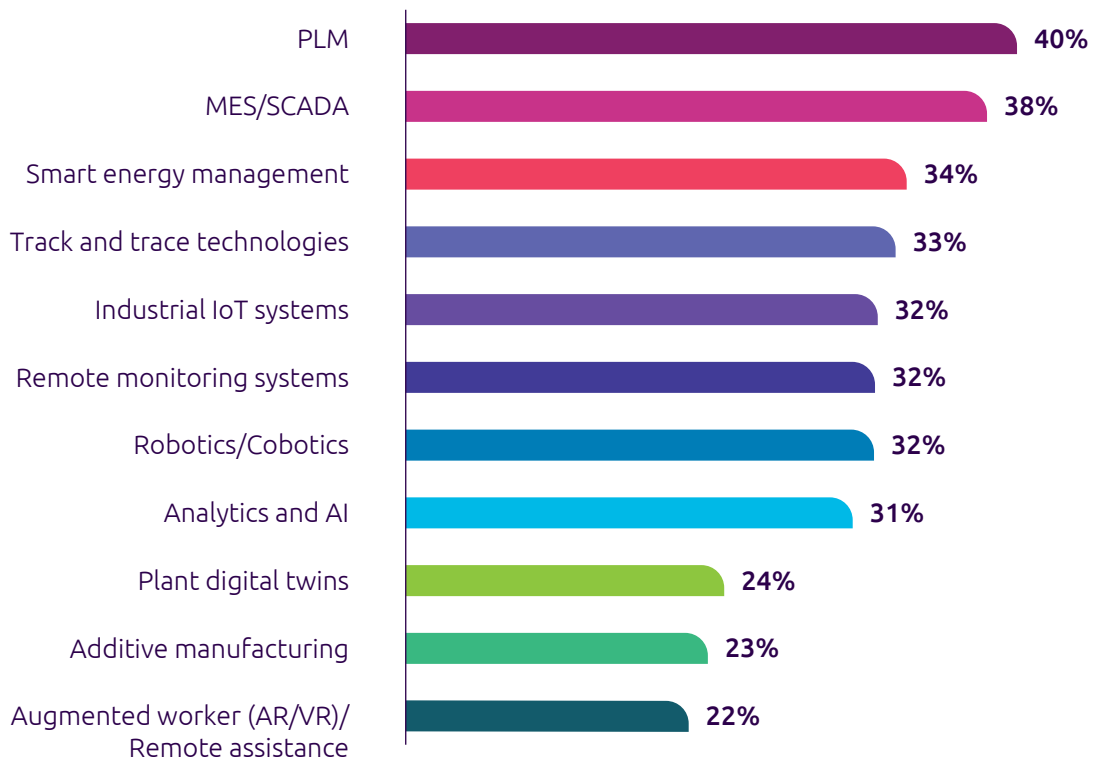
Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=1,000 manufacturers.

Challenge 1: Organizations are not prepared for scaled deployments and integrating smart factory initiatives with their legacy systems

As shown in Figure 14, the overall adoption of technologies has been low. Only 40% of production facilities, on average, are using MES/SCADA solutions, which have been in the

market for some time now. In the same way, 40% use PLM for discrete manufacturing and consumer products. Newer solutions, such as remote monitoring, mobile/augmented worker (AR/VR), and manufacturing intelligence (from Industrial IoT to analytics and AI), are yet to be deployed at more than two-third of the production lines on average.

Figure 14. Share of production lines that are currently managed by digital platforms/technologies



Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=1,000 manufacturers.

14%

The share of organizations who would consider their smart factory deployment so far, a success

Martin Widsing, senior manager – Virtual Methods and IT at Volvo Cars, points to the lack of off-the-shelf platforms as one of the key challenges. *“The biggest struggle is that there are no products and platforms available, ready to use, that we can simply purchase, implement, and then start using,”* he explains. *“They do need a lot of customization and configuration before they are actually ready to be used.”*¹⁹

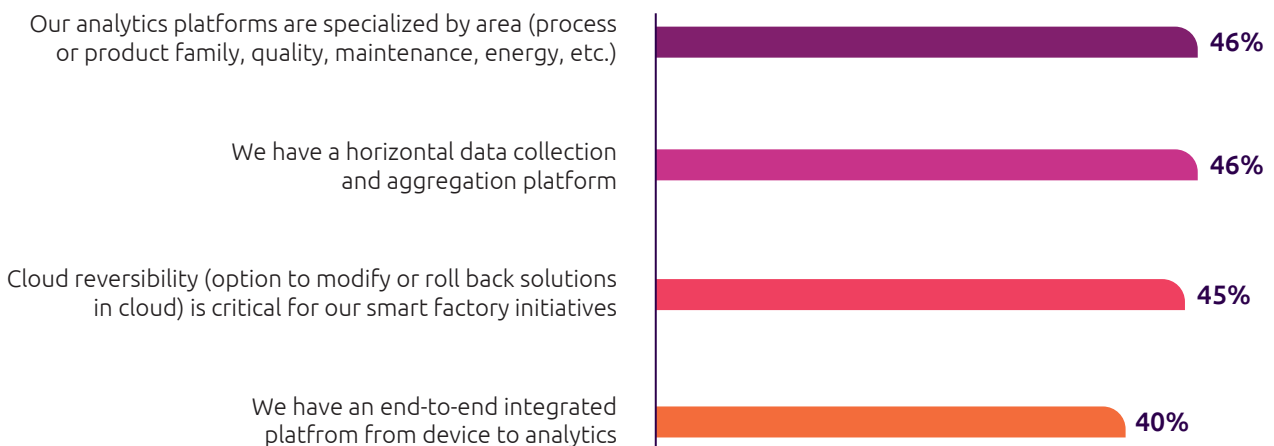
We also found that a number of organizations are not emphasizing enough on the end-to-end integration of manufacturing systems and platforms. For instance, only around half focus on integrating smart factory systems, such as MES/SCADA, with core enterprise systems such as enterprise resource planning (52% of respondents consider

this area critical) or product lifecycle management (48% consider this critical).

At the same time, platforms for collecting, aggregating, and analyzing data are not prevalent as shown in figure 15. We found that only 40% have an end-to-end integrated platform that span from device to analytics. A slightly higher number of organizations focus on a multilayer architecture (46%) and hybrid infrastructure (46%).

Nearly half (45%) consider that cloud reversibility (option to modify or rollback solutions in cloud) are critical for smart factory initiatives.

Figure 15. Organizations' focus on manufacturing intelligence



Source: Capgemini Research Institute, Smart Factory survey, April–May 2019, N=1,000 manufacturers.

>50%

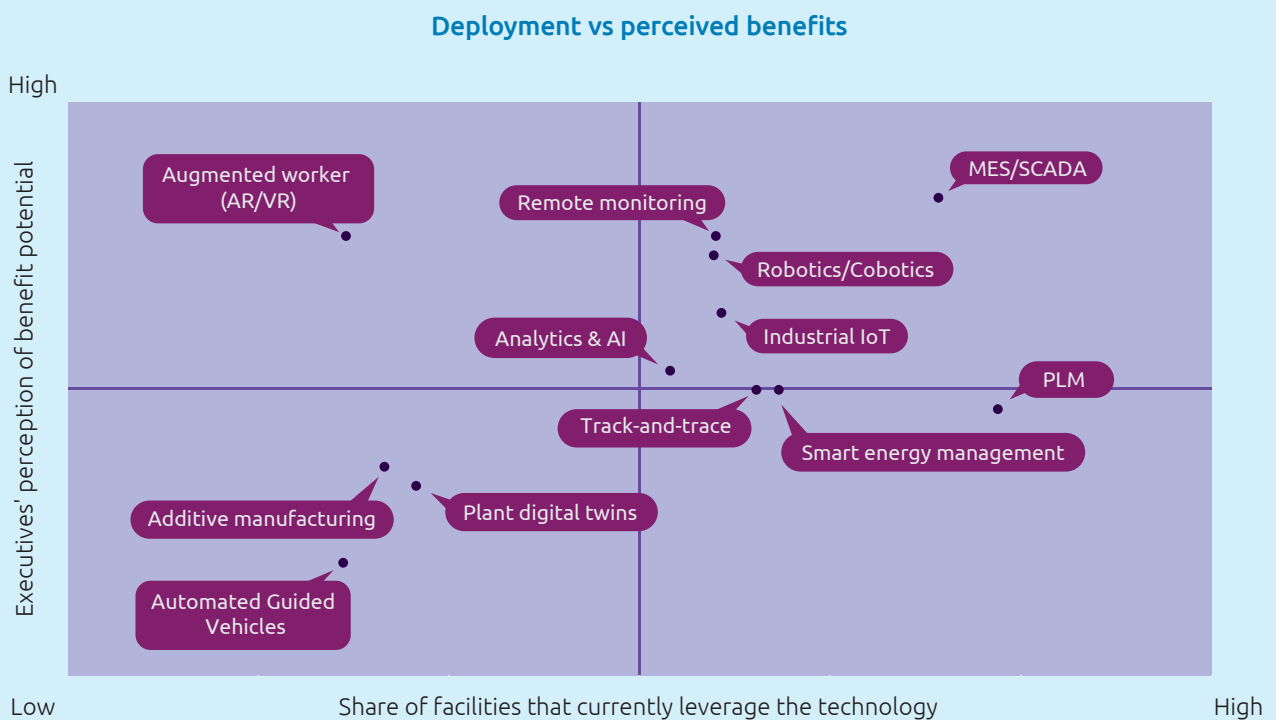
The share of organizations who find the deployment and integration of digital platforms and technologies a major challenge to scale up smart factory initiatives

Organizations are looking at a wide array of technologies to achieve their smart factory ambition

To realize smart factory gains, organizations are depending on a large set of technologies. Figure 16 shows the relative position of those technologies in terms of their perceived potential and current deployment. The following are the key insights from the figure.

- MES/SCADA as well as PLM in discrete manufacturing are the top technologies being scaled.
- Industrial IoT, analytics, and AI have fared better both in terms of deployment and benefits, along with robotics/cobotics.
- While remote monitoring is also starting to be deployed, the scaling up of “mobile/augmented worker” has not picked up yet, though executives believe both of them have the potential for a high return on investment.
- The potential of plant digital twin, a key for “efficiency by design” is yet to be realized

Figure 16. Relative positioning of technologies deployed vs perceived benefits



Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=912 manufacturers.

45%

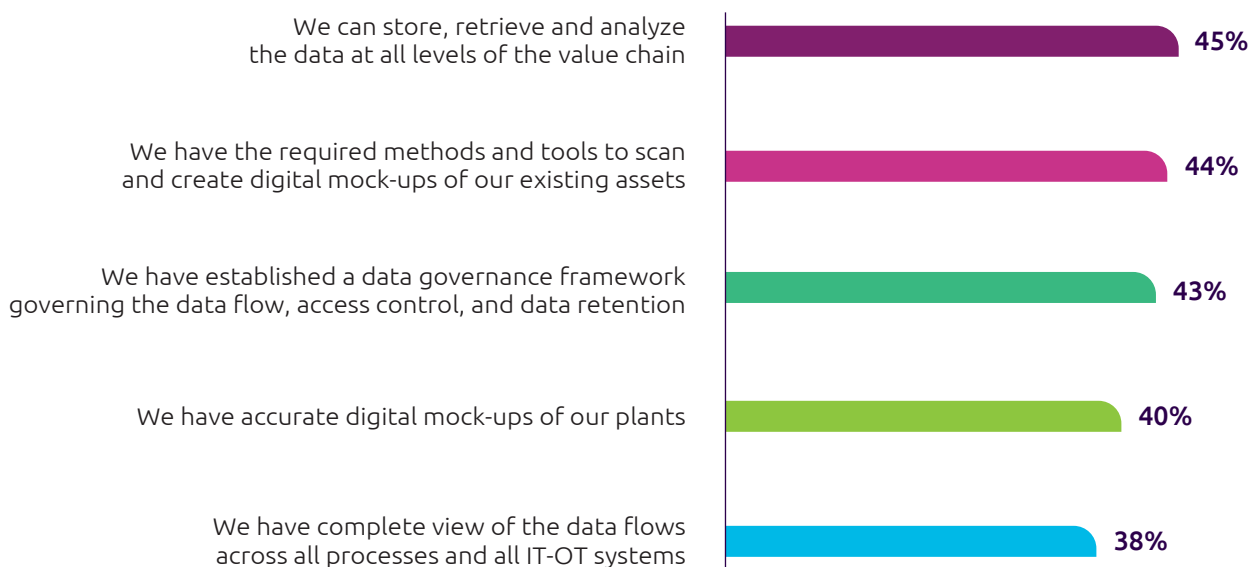
The share of organizations that can store, retrieve and analyze data at all levels of the value chain

Challenge 2: Inadequate data readiness and cybersecurity status and measures

Achieving scale will depend on how advanced organizations are at exploiting data. As Figure 17 shows, advanced data capability is relatively rare. Only 45%, for example, can access and analyze data from across their value chain. Nitin Dharmadhikari, Deputy GM at Tata Motors, emphasises how

important access for integrated data is for effective decision making. *“Supervisors or managers who have worked in the shop-floor environment for a long time can typically judge a situation and take decisions based on that,”* he says. *“However, this hampers efficiency. If integrated data is available to them, they will be able to take better decisions that will enhance efficiency.”²⁰*

Figure 17. Share of organizations with advanced data capabilities



Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=1,000 manufacturers.

Juha Ehrola, director of Operations Development at Valmet, a Finnish supplier of automation and manufacturing machinery, echoes the importance of high-quality data.

“Without good-quality data, all operational systems like ERP systems become unreliable. If the data does not have the proper structure – and lacks details such as the use of material and dates – you cannot really make use of ERP to improve your operations.”²¹

Cybersecurity: a significant battle front for manufacturers

Manufacturing is one of the prime target industries for attackers, with studies showing that nearly half of manufacturers have faced a cyberattack at some point.²²

Our research shows that, over the past 12 months, one in five manufacturers have experienced a cyberattack or a data breach (see Figure 18).

Figure 18. Prevalence of cyberattacks and data breach incidents in the last 12 months

In the last 12 months have any of your smart factory initiatives experienced the following?



Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=912 manufacturers.

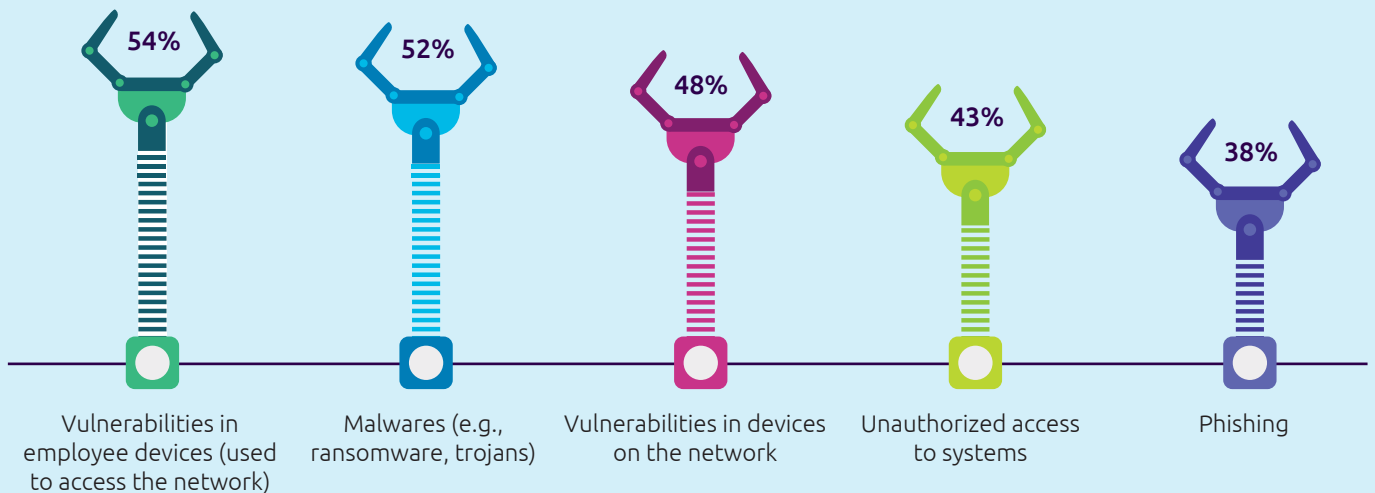
Manufacturers told us that in over half the cases two main tactics were used:

- Attackers exploiting vulnerabilities in employees' own devices to access the network
- Attackers using malware such as trojans.

Bring-your-own-device policies, as well as poor employee awareness, are contributing to organizations' vulnerability. The traditional silos of OT systems is partly a reason for the lack of manufacturers' focus on real-time cybersecurity risks.

Figure 19. More than 50% of the cyberattacks involved vulnerabilities in employee devices and malware

Top 5 reasons behind cyberattacks and data breaches



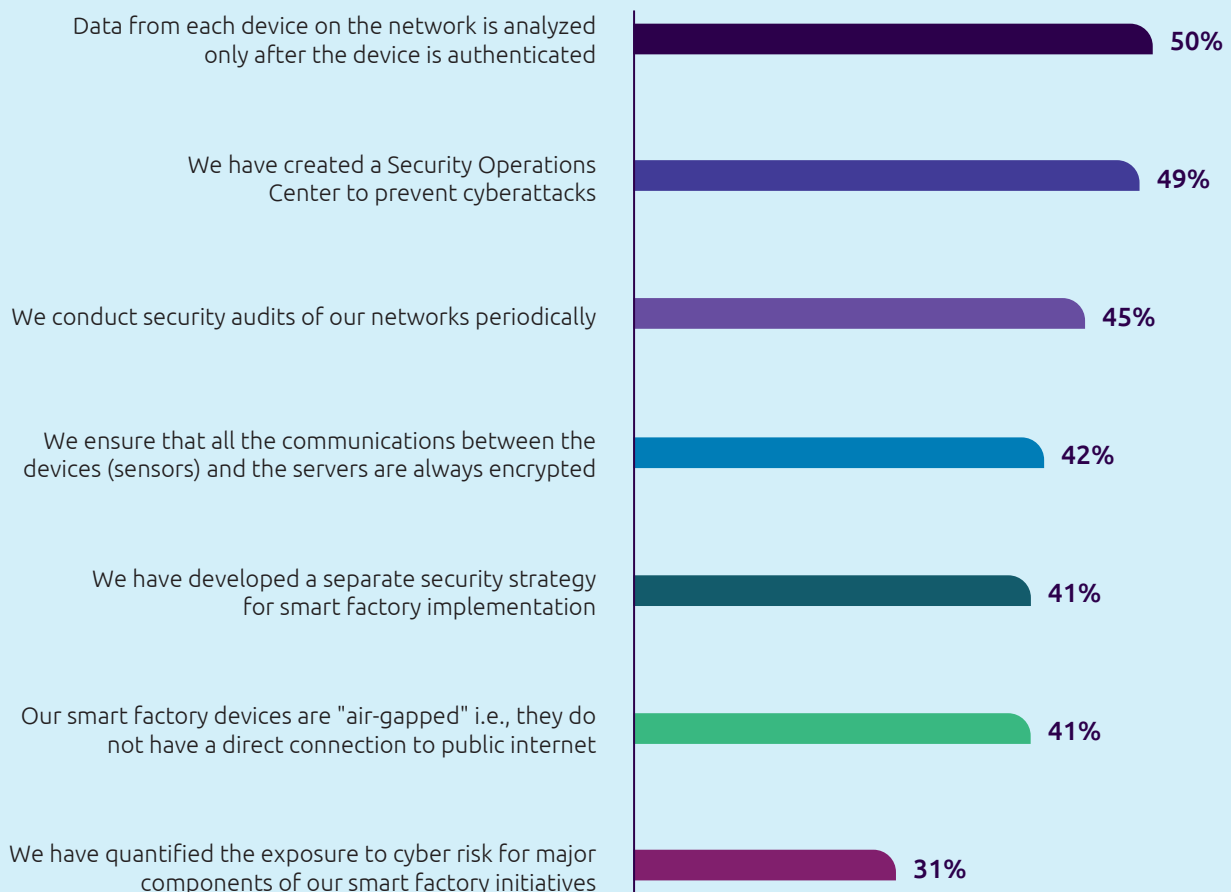
Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=272 manufacturers that faced a cyberattack.

Cybersecurity: a significant battle front for manufacturers

Despite the huge costs of a breach or attack, our research shows that not all organizations are taking sufficient measures for their security. Only 45% say they conduct periodic security audits, while only 41% “air-gap” their

smart devices (i.e., devices do not connect directly to a public internet). The growing need for IT-OT convergence and remote monitoring solutions are definitely reasons for manufacturers to critically consider the security concerns.

Figure 20. Less than half of the manufacturers are adequately prepared to deal with cybersecurity concerns



Source: Capgemini Research Institute, Smart Factory survey, April–May 2019, N=1,000 manufacturers.

Challenge 3: Organizations lack the hybrid, soft, and digital skills necessary for smart factory implementation

Organizations are hampered by a shortage in the skills required for smart factories. Because these initiatives are not just a pure technology transformation, organizations need additional skills apart from digital skills.

We have classified the required skills into three broad categories:

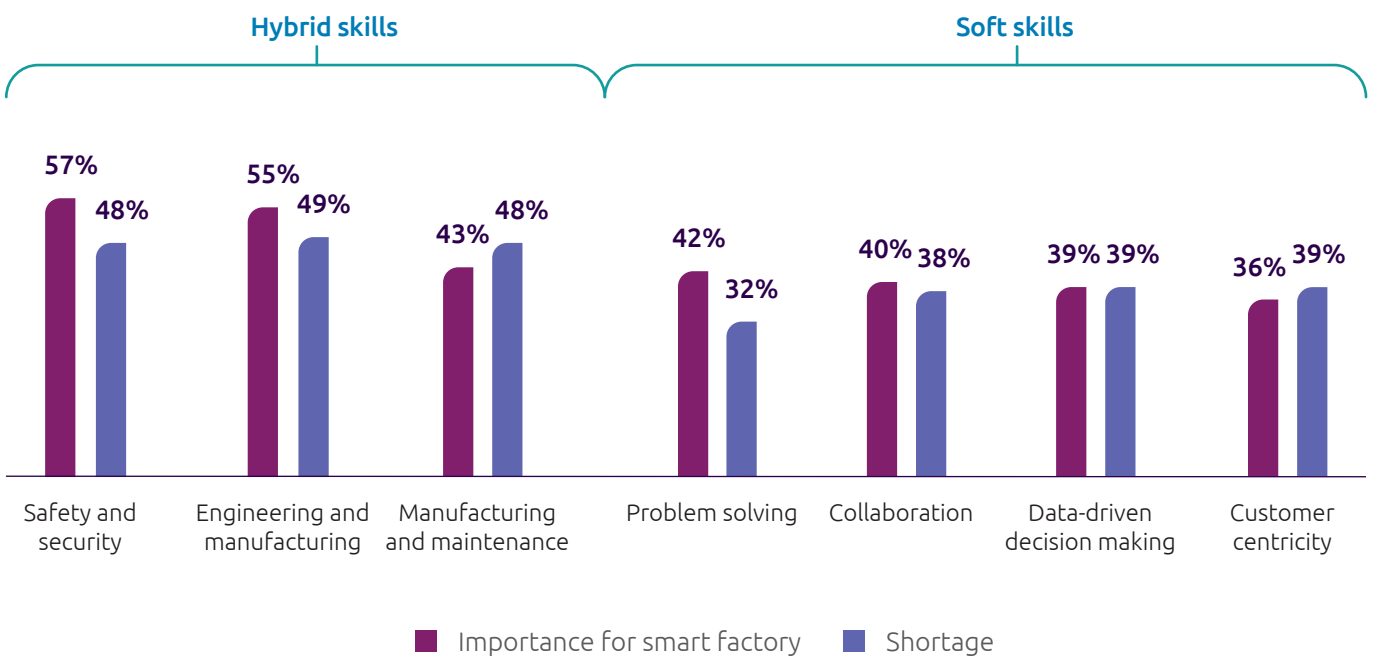
- hybrid or cross-functional skills: skills to handle tasks related to multiple functions of manufacturing, such as product engineering or manufacturing operations.

- soft-skills: these include skills such as an analytical mindset, ability to collaborate or comfort with ambiguity
- digital skills: know-how of specific digital technologies or platforms.

Below we show how these different types of skills rank in terms of their importance to smart factories, as well as the relative shortage of each skill.

Figure 21 shows the picture for hybrid and soft skills. The industry still places significant emphasis on hybrid skills above softer capabilities, and hybrid skills are also in short supply.

Figure 21. Critical hybrid and soft skills – their importance for smart factories and shortage faced currently

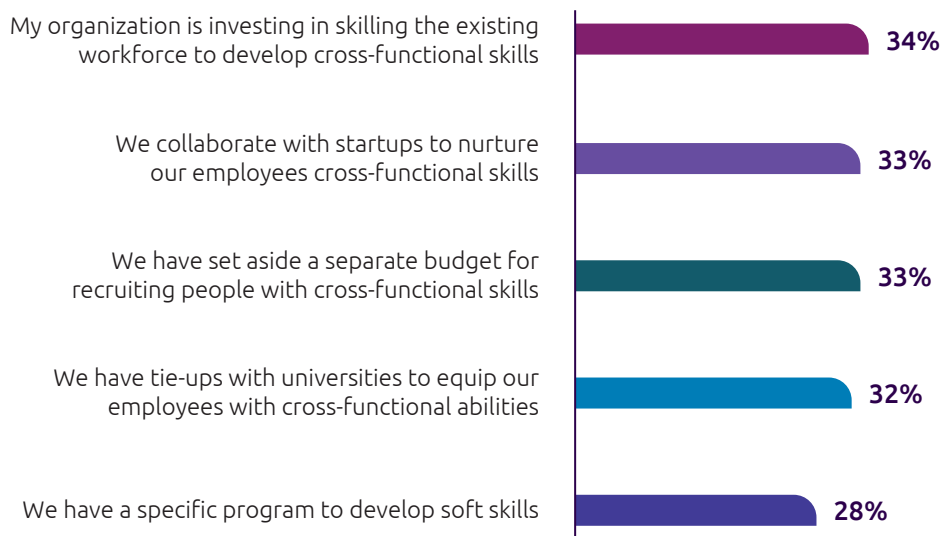


*Respondents selected the top two skills that are in shortage in their organizations.
Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=1,000 manufacturers.

Surprisingly, despite this shortage, few organizations are taking steps to resolve the issue. For example, as Figure 22

shows, only around a third (34%) are making investments in developing cross-functional skills.

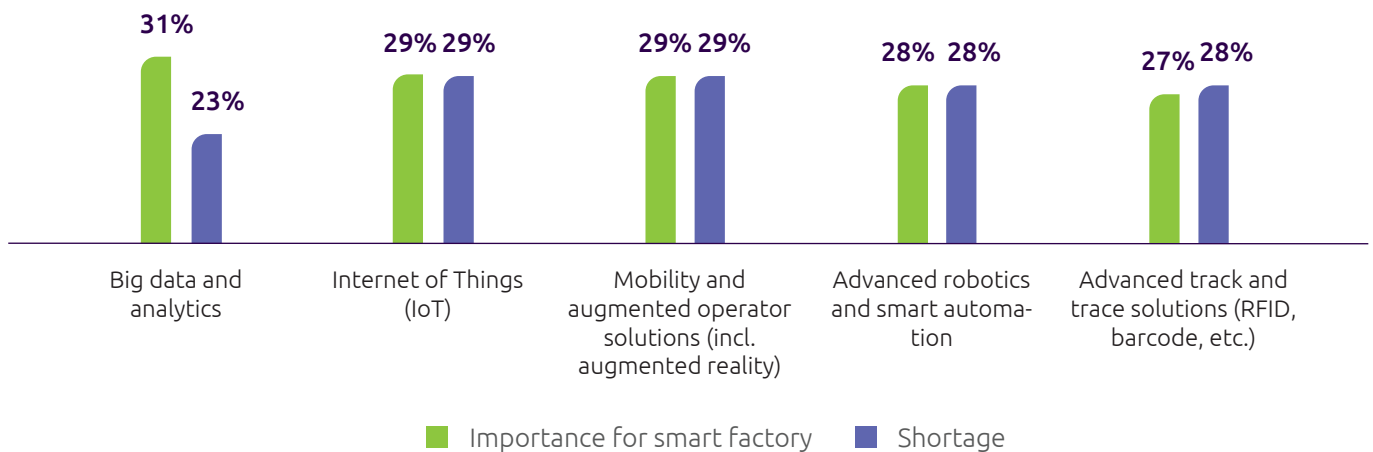
Figure 22. Organizations' efforts to bridge the skills gaps



Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=1,000 manufacturers.

Figure 23 shows the picture for digital skills, where data analytics tops the list. At the same time, close to a quarter (23%) face a shortage in this critical area.

Figure 23. Top five digital skills that are important for smart factories and their shortage



*Respondents selected the top two skills that are in shortage in their organizations.

Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=1,000 manufacturers.



4. Learning from organizations that have mastered their smart factory transformation

What do the organizations that have mastered smart factory transformation do differently?

Smart factories have the potential to deliver huge benefits. However, our research has shown that only a minority of high-performing organizations are equipped to seize those benefits.

To arrive at that conclusion, we assessed all organizations that have an ongoing smart factory initiative against a unique framework. It assesses whether they meet three objectives. Firstly, a strong IT-OT convergence which includes a command of technology capabilities. Secondly, a focus on

both efficiency by design and operational excellence while continuously ensuring virtual and physical consistency thanks to loopbacks. And finally, the capabilities required to deliver the transformation. (See “The smart factory transformation roadmap” for the dimensions that make up the framework).

Based on this analysis, we find that only a minority of companies (10%) are in a position to realize the significant benefits of smart factories. We call this high-performing group the “front runners.”

The smart factory transformation roadmap

We rated organizations based on six capability areas from our survey data that are grouped into three objectives:

OBJECTIVE ONE: IT-OT CONVERGENCE

- 1. Deployment and integration of digital platforms and technologies:**
The adoption and maturity of digital platforms and technologies in the IT-OT landscape including production.
- 2. Data readiness and cybersecurity:**
Data continuity and accessibility across the value chain while ensuring proper cybersecurity governance and norms.

OBJECTIVE TWO: DEPLOYING VIRTUAL AND LOOPBACK PRACTICES

- 3. Efficiency by design:**
The extent of optimization of production processes before physical production has even begun, using simulation and virtualization tools.
- 4. Operational excellence:**
Maximizing the effectiveness of operations by leveraging data and advanced analytics to reach “closed-loop” and, ultimately, self-optimizing operations.

OBJECTIVE THREE: TRANSFORMATION MASTERY

- 5. Vision and leadership:**
Presence of a consistent smart factory vision backed by a concrete plan to implement and execute.
- 6. Hybrid, soft, and digital capabilities:**
Availability of talent with the hybrid/cross-functional, soft, and digital skills needed, along with organizations’ abilities in upskilling their employees

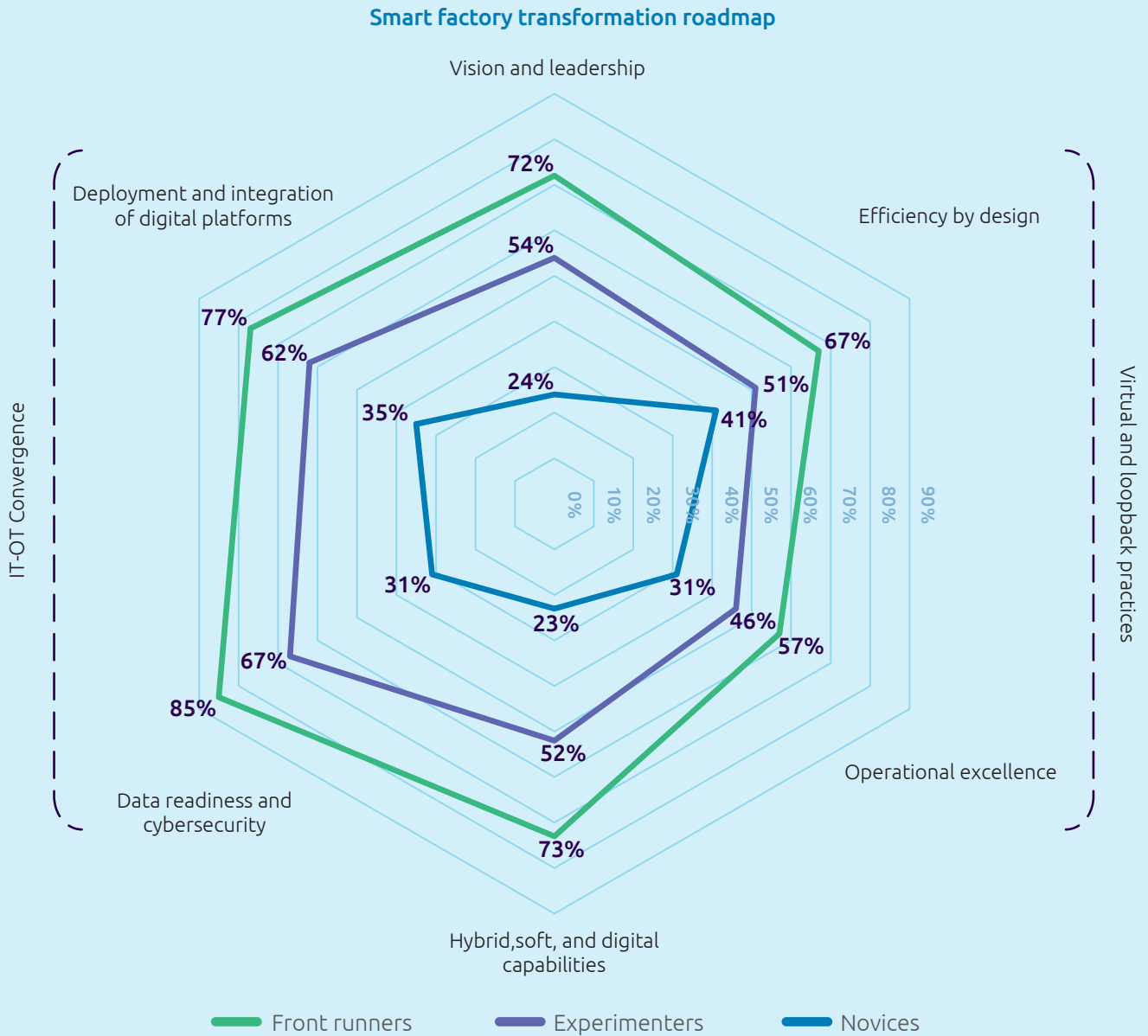
Based on this framework, the following cohorts emerge:

- **Novices (75% of sample):** lack most of the capabilities in these six dimensions.
- **Experimenters (15%):** perform well in some of the six dimensions, but lag behind in the others
- **Front runners (10% of sample):** This high-performing cohort outperforms all the other groups on all dimensions of smart factory transformation.

10%

The share of organizations that excel in all six capability areas

Figure 24. Front runners consistently outperform others

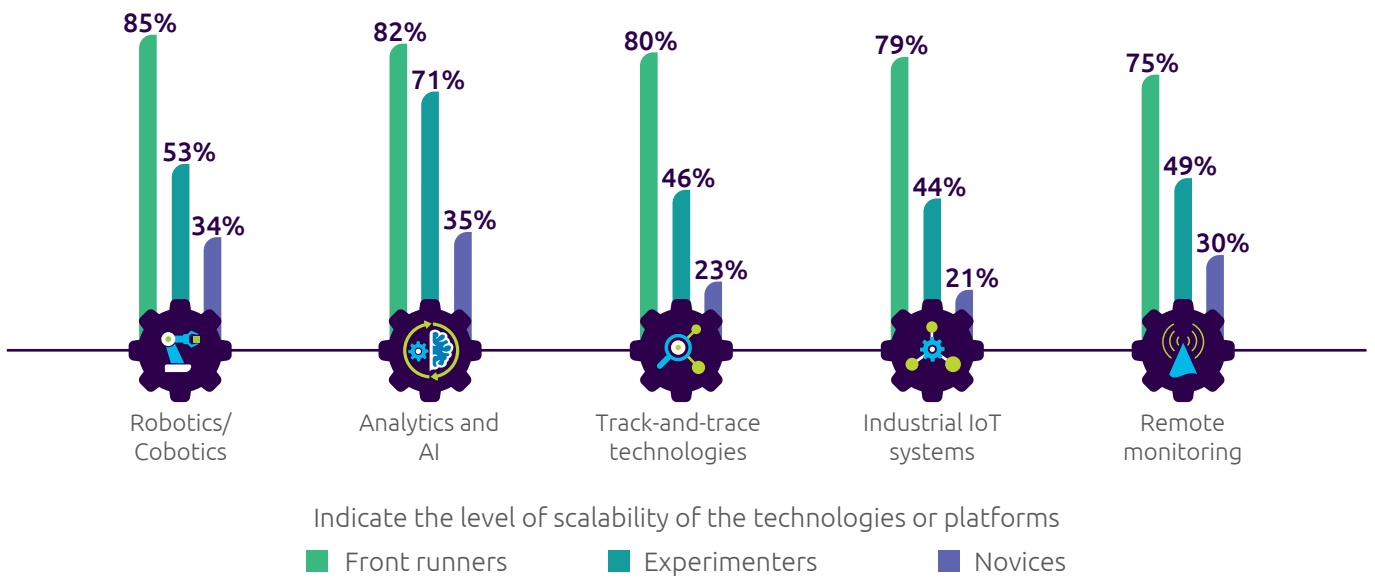


Note: Scores on each axis are rated from 0 to 100%, with 100% being a perfect score.
 Source: Capgemini Research Institute, Smart Factory survey, April–May 2019, N=912 manufacturers.

Front runners are better at getting to scale (see Figure 25) and seize a greater benefit prize (see Figure 26). For instance, Schneider Electric’s first smart factory in the United States

has tracked quantifiable benefits from IIoT implementation, including a 20% reduction in mean time to repair and a 90% elimination in paperwork.²³

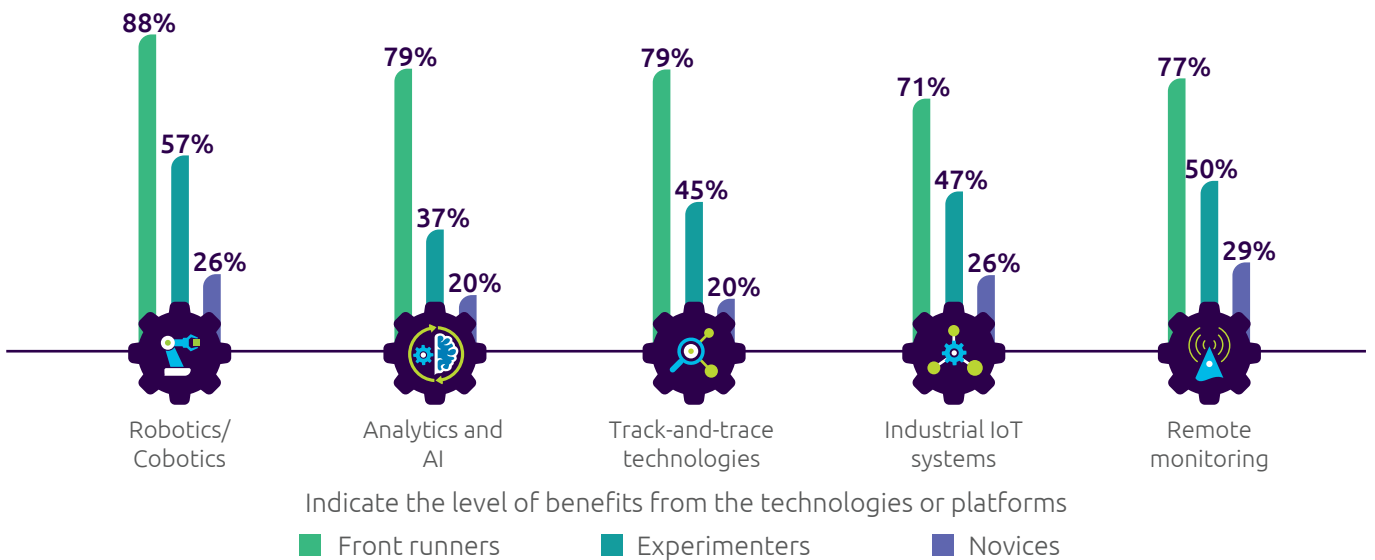
Figure 25. Front runners can scale better than others



Top five technologies at scale by front runners are shown.

Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=912 manufacturers, N=91 front runners.

Figure 26. Front runners also expect more benefits



Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=912 manufacturers, N=91 front runners.



5. How to accelerate and secure smart factory transformation

Organizations realize the huge potential offered by smart factories and are already on the path of transformation. However, as we saw in the previous sections, scaling these initiatives is proving a fundamental challenge. Drawing on our survey analysis and what it tells about the characteristics of front runners – as well as our experience of advising manufacturers around the world – we have identified four broad areas where organizations need to focus to drive scaled success.

Put in place strong governance, as well as metrics and methodologies to assess progress

Capgemini's global research into digital transformation – "Understanding digital mastery today" – identified governance as one of the most fundamental challenges in driving enterprise digitization.²⁴ Strong governance is instrumental in turning vision into reality, with smart factory program governance helping to:

- align projects to the overall strategy with strong portfolio management, so that pilots are designed for scale from the get-go and progressively build towards closed-loop operations
- manage the platform roadmap, with a specific focus on data integrity in the context of the overall enterprise architecture
- assign roles and KPIs to transformation objectives

- design metrics and methodologies to track the success of the initiatives
- monitor progress and ensure the program does not deviate from its core objectives.

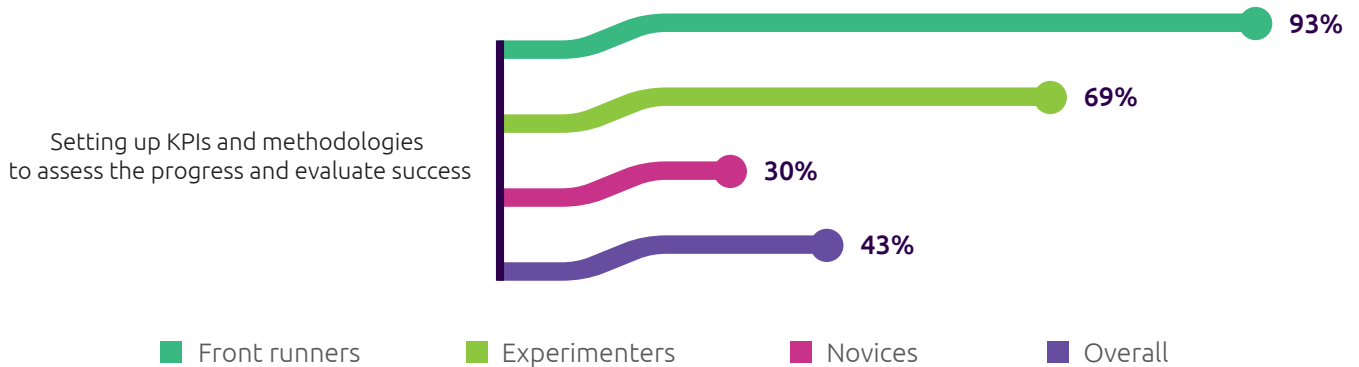
Nearly all front runners (93%) track the progress of smart factory initiatives through various lenses, compared to 43% of the overall sample. One way to assess the progress is to monitor a KPI such as OEE or capacity utilization, or any other measure that is impacted by the smart factory initiative.

Often, improvements in some metrics could be attributed to more than one project. Pascal Renouvin, VP – CIO Global Supply Chain for Renewable Energy, GE Renewable Energy, outlines how they approach assessing collective benefits.

*"We make an estimate of improvement for the proof of concept," he explains. "But after that, we don't measure deployment by deployment. But what we do know is, factory by factory, how we were at the end of the previous year and where we landed at the end of the year. For example, we have improved cash flow, or productivity, or inventory return. So, we know exactly – plant by plant – what the dollar benefits are. We then agree with the key people involved – program leader, plant leader, IT head – on a fair percentage for each of them."*²⁵

Figure 27. Front runners set up metrics and design ways to track the progress of their initiatives

Key steps that your organization has been taking to solve smart factory implementation challenges: governance



Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=912 manufacturers, N=91 front runners.

Develop a program for deploying and integrating digital platforms across manufacturing operations

As we saw earlier, scaling, deploying and integrating digital platforms across manufacturing operations is the most critical challenge that organizations struggle with. Fewer than one-third of organizations have scaled Industrial IoT or analytics and AI. Remote monitoring and mobile/augmented worker are also not deployed significantly as shown in Figure 14.

While piecemeal or focused technology deployments can still deliver benefits, the focus should be on deploying platforms that drive smart factory improvements across the factory footprint. This allows you to leverage the full potential of technologies. Organizations can achieve this by designing an enterprise IT-OT strategy at a group-level, rather than allowing the local teams to drive developments. Digital manufacturing platforms offer multiple benefits: connecting the physical world to IT world, enabling development of applications on top, making data available for mining and analytics.

Another area of focus is cloud-enabled solutions. They provide visibility into enterprise-wide data which will help in achieving efficiencies across factories, across the value chain. They are also more elastic/scalable. A hybrid architecture will be useful since organizations might not prefer cloud solutions for all their requirements.

Develop a culture of data-driven operations

Earlier in this report, we have seen how closed-loop operations and efficiency by design contribute to operational excellence. However, there is evidence that organizations are lagging in this area. For example, just one-third are using a predictive approach to make decisions about production scheduling. With manufacturers often using a variety of solution providers for MES or PLM, data becomes confined to silos.

Data silos are a significant problem as smart factories depend on the right data being available. Our research shows that only a minority of organizations have a complete view of the data flows across their process and IT-OT systems. With the number of sensors inside as well as outside a factory increasing, data volumes are only going to grow, and organizations need to have a clearly defined way to manage this data explosion. They should be able to:

- Store, retrieve, and analyze data at the required granularity
- Standardize commonly used data across platforms, locations
- Create digital mock-ups of various assets
- Make data visualization and analytics tools available
- Establish a data governance framework that can govern the principles of areas such as access, retention and deletion.

Data lakes could be one of the ways to store both relational and non-relational data from a variety of solutions, IoT devices. In order to establish a data-driven culture, along with availability of data, organizations should also focus on developing talent with an analytical mindset who can leverage the tools and take the necessary decisions.

Develop hybrid and soft skills through cross-functional career paths, upskilling and recruitment

Production systems are increasingly becoming more complex. Collaborative capabilities will be key to continuously improve operations while consistently increasing industrial know how. However, as seen previously, organizations are facing shortages in hybrid, soft, and also digital skills.

Organizations should take a long-term approach in bridging this profound skill gap across areas. Our research shows that front runners grasp this imperative. As seen in Figure 28, they focus not only on digital skills but also on soft skills.

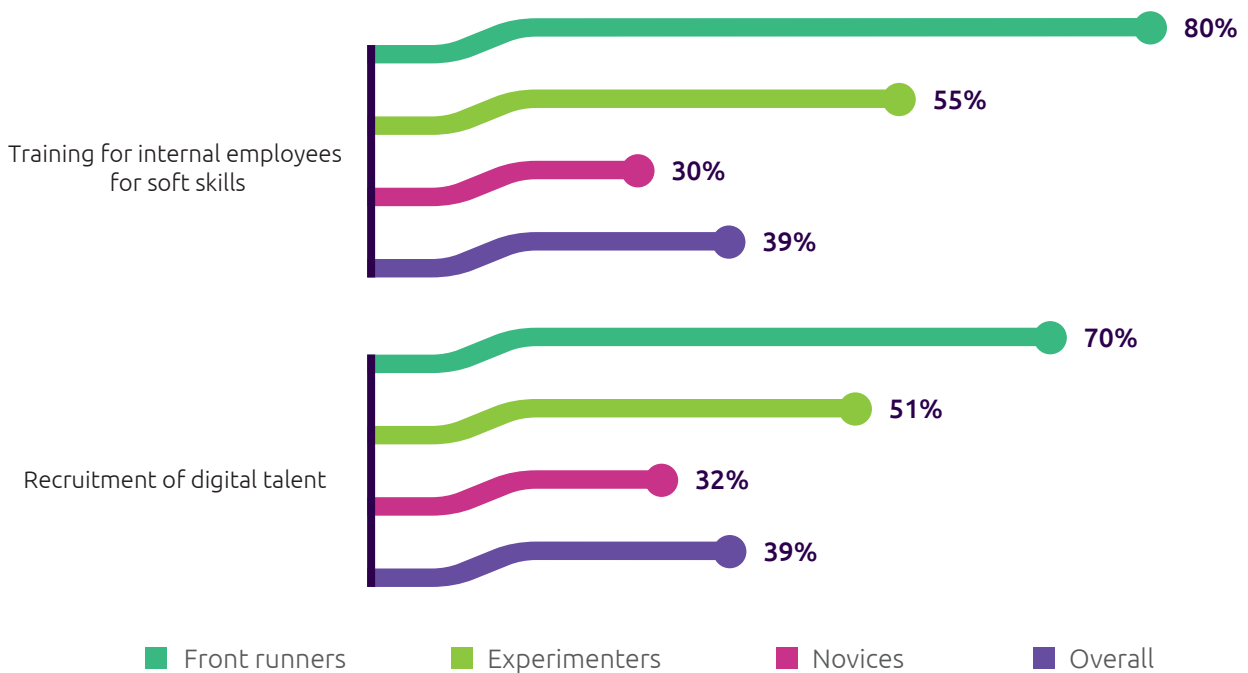
Organizations need to begin by understanding where they lack skills for today's challenges, but also where skills will be lacking to meet long-term, future challenges as market environments and technologies change. As well as recruiting to plug urgent needs, bridging the gap will involve:

- Developing a skill matrix (current skillset vs aspiring/future skills) for employees
- Designing and conducting employee upskilling programs
- Designing career programs that allow employees to pursue career paths across functions – this will help in building hybrid/cross-functional skill set
- Focusing on training programs that emphasize on soft skills, such as collaboration and a digital-first mindset.

Organizations can strengthen their training programs in various ways: classroom trainings, internal learning management systems to e-learning platforms. Continuous emphasis on upskilling and rewarding employees when they acquire new skills will help in bridging the gap.

Figure 28. Front runners bridge their skill gap through upskilling and recruitment

Key steps that your organization has been taking to solve smart factory implementation challenges: skill shortage



Source: Capgemini Research Institute, Smart factory survey, April–May 2019, N=912 manufacturers, N=91 front runners.

As well as drawing out the best practices of front runners, we have also identified further areas of improvement for both novices and experimenters:

Novices need to think big and start small

Novices have the opportunity of learning from front runners by addressing foundational capabilities in parallel with the first pilots. There are a number of priorities that will be key:

- **Assign an executive to oversee the transformation program**

Less than a third (32%) have assigned a specific leader to oversee the smart factory transformation activities (against 56% of front runners).

Smart factory transformation involves a multi-year, large-scale, cross-functional transformation – and the transformation objectives are both tactical (such as improving OEE or reducing operational costs) and strategic (such as innovation, creation of new business opportunities). Such a transformation requires multi-discipline change, including changes in processes and culture, and training as well as management support. It therefore requires strong leadership and senior management support to ensure the program meets its objectives.

- **Invest in IT-OT convergence and cybersecurity**

With the proliferation of IoT, the focus and the importance of OT is on the rise. However, the silos between IT and OT impede operational efficiency.

Organizations should invest in integrating their IT and OT platforms and core business systems such as MES. While investments are one factor, organizations should also ensure they break the silos between the IT and the OT teams. The teams must work effectively together if an organization is to generate strategic insight.

Stanley Black & Decker Inc., an S&P 500 consumer and industrial power tool company, has used IT-OT convergence to develop a coherent solution to manage a complex production of three dozen models of power tools. The production lines require quick changeovers and efficient management of assets. The company used a real time location system using Wi-Fi and RFID enabling remote monitoring of production. With the OT systems feeding information to the frontend IT systems, Stanley Black & Decker was able to improve OEE by 24%, labor utilization from 80% to 92%, and increase throughput by around 10%.²⁶

Another significant factor is cybersecurity. The increase in the number of smart devices poses a significant challenge and we have seen how many organizations do not have robust security measures. Improvement areas can include:

- mapping all entry and exit points of data
- securing networks through mechanisms such as firewalls or intrusion detection systems
- “air-gapping” smart factory devices
- adopting “security by design” principles
- periodic security audits
- response strategy and plan to manage the implications of an attack
- awareness of security threats and the culture of following best practices.

- **Assess the maturity and determine the roadmap for each factory**

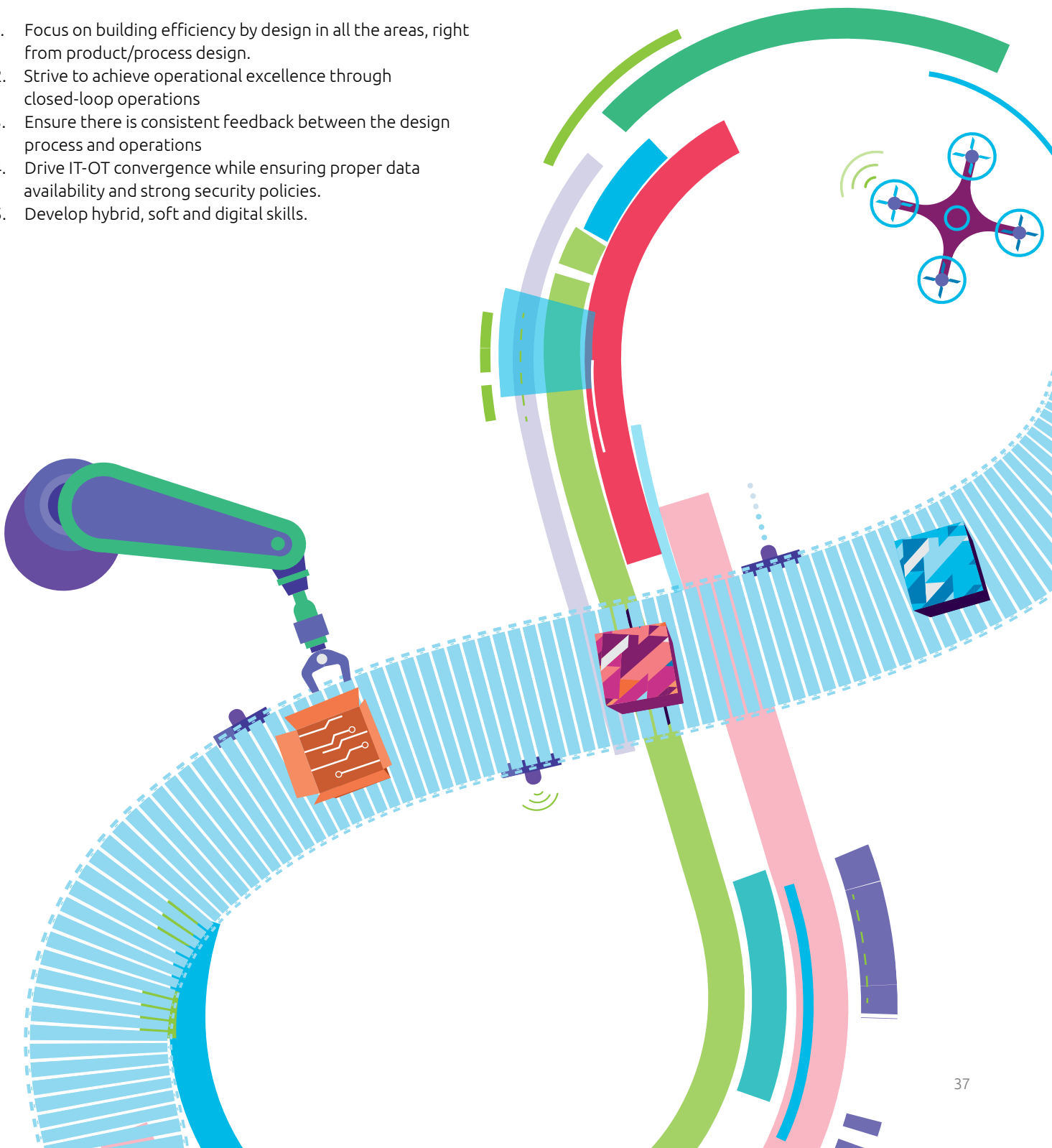
The age and digitization of individual factories in an organization will vary. Organizations should therefore have a framework to help them do the following:

- Evaluate current maturity from a digital standpoint
- Assess where they want each factory to be in the next three or five years
- Determine the tools and the programs to help them move up the maturity curve
- Initiate pilots, small scale testing projects, across different factories in different areas to create momentum and fuel the spiral of success. Pilot projects can be extremely useful in developing a good understanding of technologies and identifying the use cases where a certain technology add most value to. Volvo Cars’ Martin Widsing outlines how they are learning from different pilots and experiments taking place across the organization. *“We are doing this in small steps to make sure that we learn the technology and find a common standard, using one plant as a pilot,”* he explains. *“But we will also leverage the strength of having several plants, so there will be different development topics in each area. For example, we have one plant taking the lead in big data – one focusing a lot more on the MES and ERP side and others focused on automation.”²⁷*

Experimenters need to invest into their foundations before attempting to scale up

Front runners realize the full potential of smart factories by ensuring that they have the right foundations in place and then continuing to improve them. In addition to a robust vision and a comprehensive roadmap for the smart factory journey, experimenters should then:

1. Focus on building efficiency by design in all the areas, right from product/process design.
2. Strive to achieve operational excellence through closed-loop operations
3. Ensure there is consistent feedback between the design process and operations
4. Drive IT-OT convergence while ensuring proper data availability and strong security policies.
5. Develop hybrid, soft and digital skills.



How can Capgemini help your smart factory transformation?

Capgemini – a leading provider of services for the ‘Intelligent Industry’ – offers a complete portfolio of services, reference architectures, platforms and solutions to accelerate and secure your smart factory program by helping you with:

- designing architecture for performance at scale
- accelerating and securing physical-digital convergence
- deploying and integrating digital platforms to ensure digital continuity and fuel extended collaborations
- breaking “silos” with collaborative and agile ways of working
- empowering your people and mastering the digital workforce
- delivering results to ensure success.

Capgemini reference architectures, platforms and solutions are agnostic, secure, ready to go and scale up.

From consulting to technology services

Our end-to-end assistance to your smart factory journey includes:

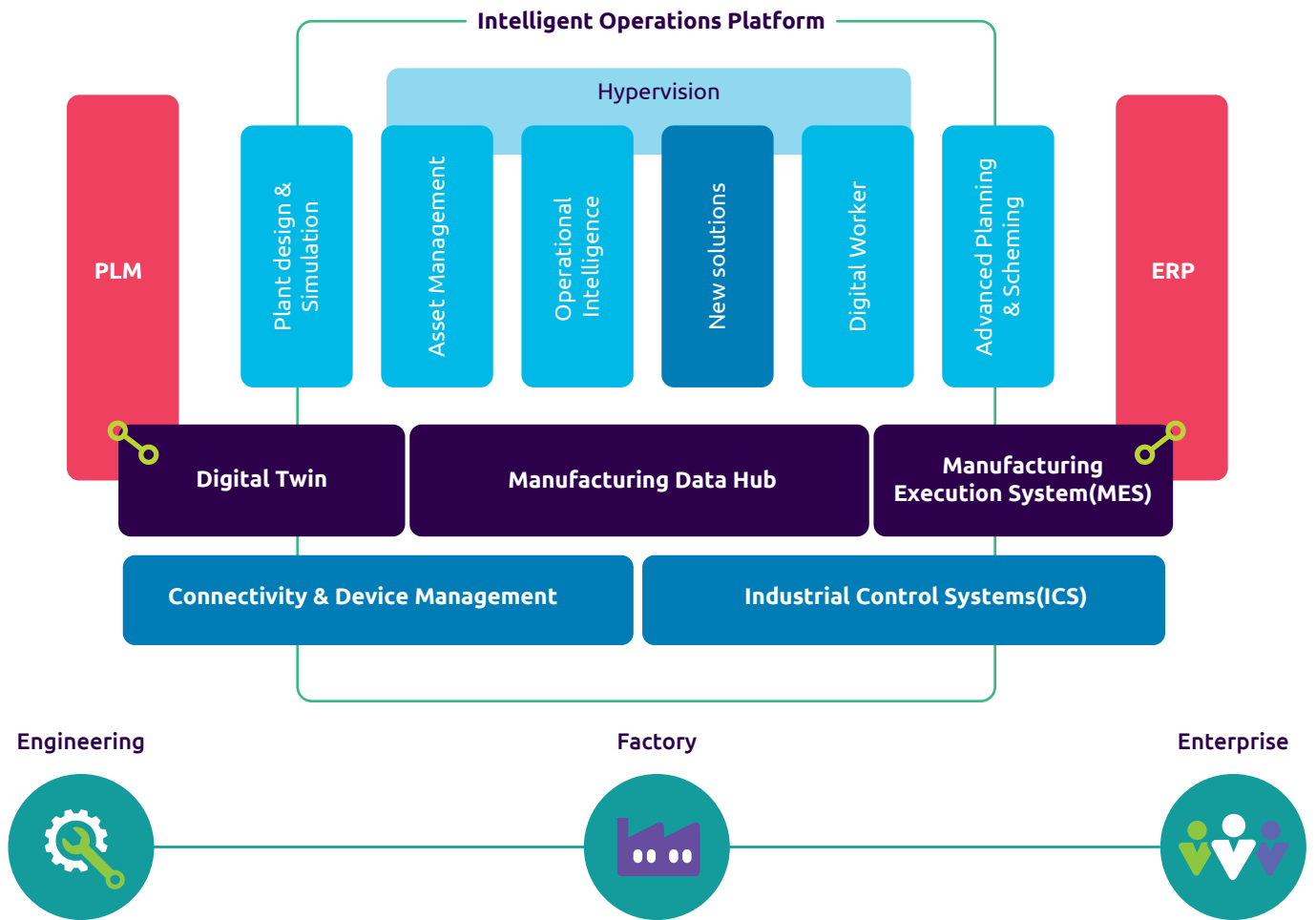
- Smart factory analysis and design: complete assessment of the smart factory maturity, defining the strategy for scaling up and design of a consistent transformation roadmap comprising use cases, quick wins, digital platforms and IT-OT convergence, benefit cases, governance, change management
- Platforms and solutions’ set up - from business, architecture and IT design to build and deploy:
 - MES/SCADA
 - Asset management
 - Digital platforms: IIOT, analytics and AI, remote and mobile, digital twin and others
 - IT-OT architecture and integration/roadmap for convergence
- Smart factory applications’ maintenance
- Smart factory platforms and solutions as a service.

Smart factory reference architecture and platform

Capgemini’s Smart Factory offer is designed around an integrated modular platform to accelerate and achieve the required scale with digital transformation for global manufacturers. The platform extends to provide the complete:

Horizontal process coverage: from the interface to product and process planning data - typically managed in a PLM application, to the ERP application on the other end. The ERP application interfaces the manufacturing data into the enterprise.

Vertical integration of manufacturing technology layers: from shop floor connectivity to advanced analytics and point solutions and applications for targeted users. The goal is to enable a seamless manufacturing stack.



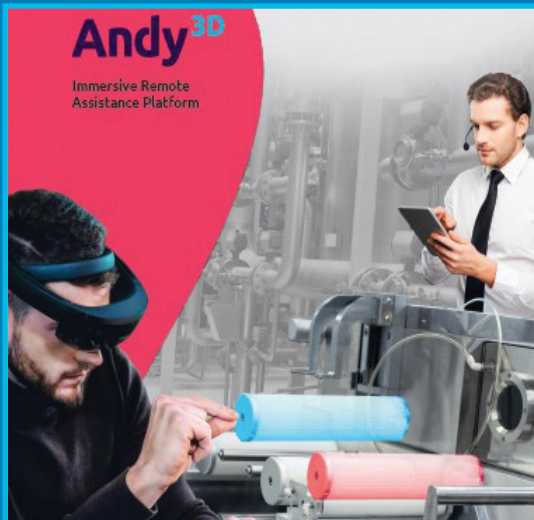
To support data-driven operations, the Intelligent Operations Platform allows manufacturers to extend their traditional MES with flexible and scalable data management and analytics capabilities. This brings dimensions of intelligence and analytics and enables a true operations platform as opposed to just a dashboard. The Intelligent Operations Platform is at the heart of our Smart Factory Operating Model design.

Smart Factory @ Scale with our integrated modular platform

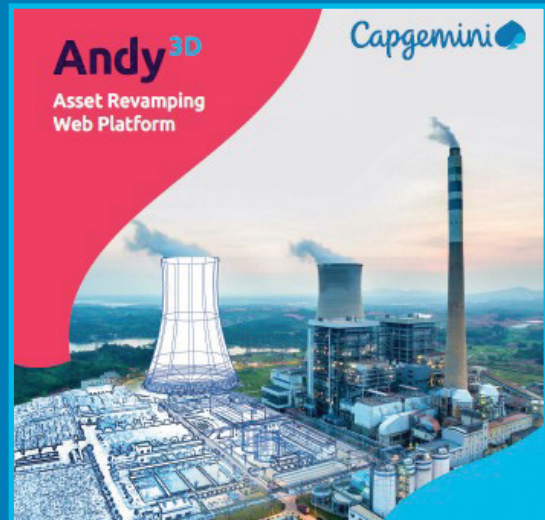
Building the Smart Factory on an integrated platform allows organizations to combine fast incremental innovation with deployment at scale. Issue-focused applications/ transversal solutions combine the agility of bottom-up innovation and the scalability that delivers tangible results. When combined with our integrated governance, from technology to culture change, platform-based innovation allows a sustainable transformation towards Industry 4.0.

Our Smart Factory offer leverages the flexibility of Industrial IoT platforms, alongside existing manufacturing systems to get the full potential of Industry 4.0 “one application at a time”.

Solutions dedicated to smart factory



Andy remote: A complete multi-channel platform providing digital continuity of 3D models



Andy asset revamping: Provides real, interactive and easy-to-use mock-ups hybridizing 3D models and point cloud, in a web browser from any device



X-IoT: A fully configurable and technology-agnostic solution to securely connect and manage your products and assets



Reflect ioD: Information Modeling through integrating natively 1D, 2D, 3D, geographical information and IoT data

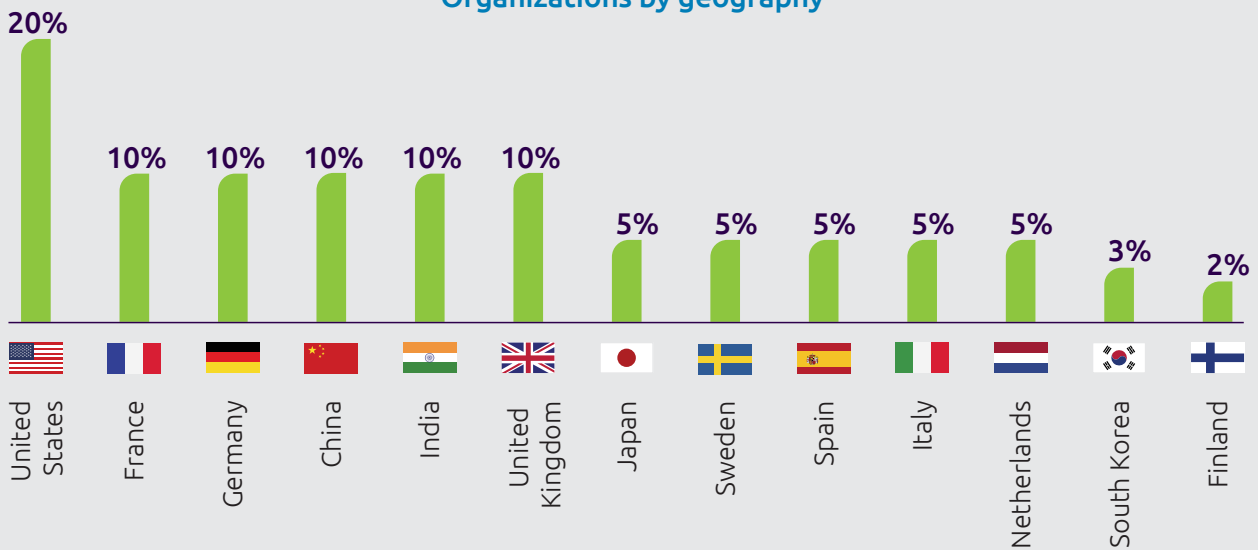
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Smart Factories: How can manufacturers realize the potential of digital industrial revolution, Unlocking the business value of IoT in operations, Digital Engineering: The new growth engine for discrete manufacturers, The Digital Supply Chain’s Missing Link: Focus, 5G in industrial operations: How telcos and industrial companies stand to benefit.
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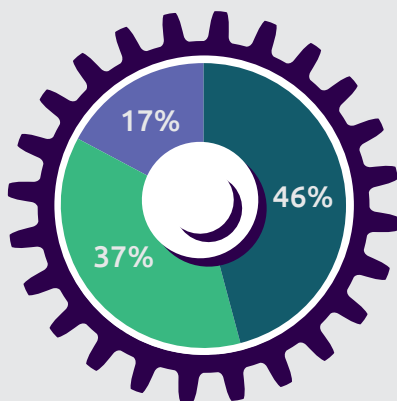
Research Methodology

This research followed a two-pronged approach. We surveyed 1,000 executives in organizations that had a smart factory initiative underway. All these organizations reported revenue of more than \$1 billion for the last financial year. The survey took place from April to May 2019 and covered thirteen countries.

Organizations by geography

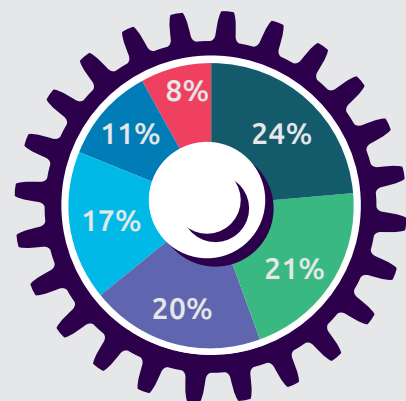


Organizations by revenue



- Between \$1 billion and \$5 billion USD
- Between \$5 billion and \$10 billion USD
- \$10 billion USD and more

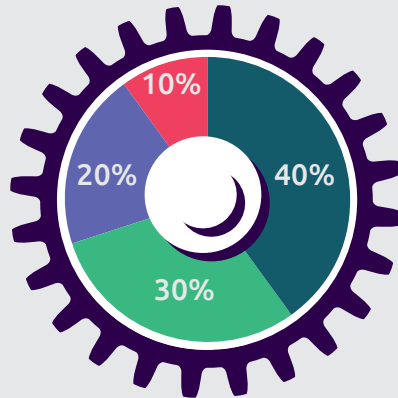
Respondents by designation



- Plant manager (managing one plant)
- General manager of plants
- Director/Senior Director
- C-suite executives
- AVP/VP/Senior VP/Executive VP
- CEO

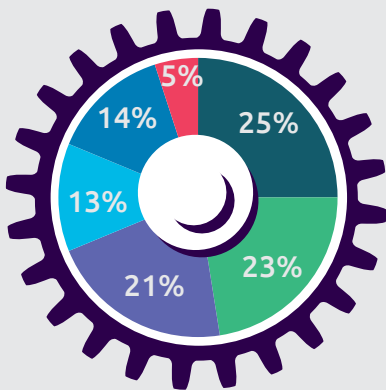
We also conducted in-depth interviews with more than 20 academics, industry experts, and entrepreneurs.

Organizations by industry



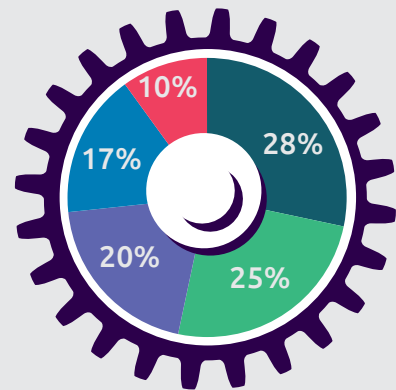
- Discrete manufacturing
- Process industries
- Power, energy and utilities
- Consumer products

Sub-industries in discrete manufacturing



- Automotive
- Transportation
- Industrial machinery
- Medical devices
- Semiconductor and electronics/High-Tech
- Aerospace

Sub-industries in process manufacturing



- Pharmaceuticals
- Mines and metals
- Chemicals
- Paper
- Cable

In addition to the survey, we also conducted nearly twenty in-depth discussions with executives overseeing a smart factory initiative or a smart factory. In these interviews, we discussed on the vision, the approach for smart factories, benefits, and the challenges in scaling the initiatives.

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Jean-Pierre is the Capgemini Group leader for Digital Manufacturing. He earlier managed the Manufacturing, Distribution, Retail and Energy & Utilities sectors and was nominated deputy Chief Executive Officer of our technology Services in France, in January 2013. He was appointed Chief Executive Officer of Sogeti High Tech in 2015. His main mission was to develop the Sogeti High Tech Engineering and digital manufacturing presence within large companies. Jean-Pierre Petit is a SUPELEC graduate and started his career in 1984 as a consultant within Andersen Consulting. He joined the Sagem Group in 1993 heading the R&D and cable manufacturing activities.



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Alexandre is part of the Capgemini Industry 4.0, Digital Manufacturing, PLM and AI Team. Previously at Tesla, he has played an important role in driving Digital Manufacturing and PLM implementation using the 3DEXperience platform. With over twenty years of being involved in all aspects of the Engineering and Manufacturing processes, Alexandre continues to share his vision of the symbiotic relationship of each step of the process from concept to product delivery.



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Pascal is the global CTO and North America leader for Capgemini's Digital Manufacturing services. He has 30 years of experience including a seven-year stint as a Group CTO with Schneider Electric and ten years with SAP AG as a Chief Strategy Officer. At Capgemini, Pascal is responsible for orchestrating and developing the company's strategy and portfolio of solutions for the Industry 4.0/IIoT/ Digital Manufacturing market and organizing the go-to market for the related solutions.



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The Capgemini Research Institute is Capgemini's in-house think tank on all things digital. The Institute publishes research on the impact of digital technologies on large traditional businesses. The team draws on the worldwide network of Capgemini specialists and works closely with academic and technology partners. The Institute has dedicated research centers in India, the United Kingdom, and the United States. It was recently ranked number one in the world for the quality of its research by independent analysts. Visit us at www.capgemini.com/researchinstitute/

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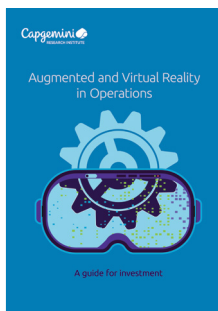
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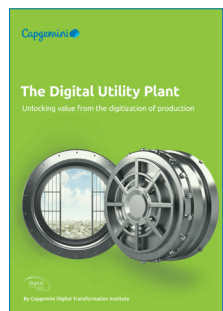
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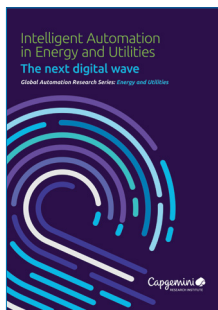
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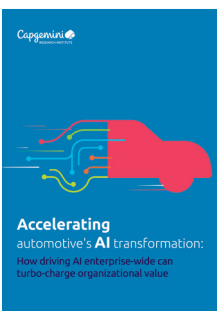
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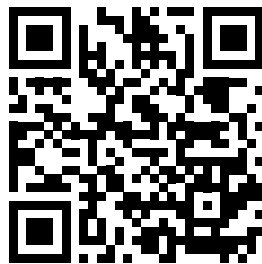
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