PwC Digital Factory Transformation Survey 2022

Digital backbone, use cases and technologies, organizational setup, strategy and roadmap, investment focus

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PwC Digital Factory Transformation Survey 2022

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Digital factory transformation is paramount in times of crisis

Industrial manufacturing companies are going through a time of unprecedented crisis: the global COVID-19 pandemic has disrupted established supply chains, causing extensive delivery challenges and significantly increased volatility of demand. The political crisis in Eastern Europe is putting additional strain on the existing manufacturing footprint, requiring a redistribution of production volumes. The resulting shortage of key materials, from microchips and electronic components to steel and base materials is hindering the manufacturing of complete products and significantly increasing input costs.

These operational challenges are combining and interacting, pushing large manufacturing companies to rethink their operating models, and driving a shift in digital strategy imperatives: leading manufacturers are now implementing digital solutions that drive higher production flexibility and better delivery resilience. These solutions include integrated operations planning solutions, quality and maintenance analytics, digital twins, or advanced visibility and KPI dashboards. The capability to deliver in the face of volatile demands and shifting supply chain configurations is gaining importance. Efficiency improvements, such as through factory automation or AI-based efficiency solutions remain high on the priority list of digital manufacturing champions.

Using digital solutions to drive environmental sustainability is also gaining importance. Increasing environmental legislation around the globe, pressure from capital markets and increasing customer demands force companies to demonstrate more than mediocre improvements, and to achieve a step change in driving down CO_2 emissions, for example via AI-based energy management solutions.

The PwC Digital Factory Transformation Survey 2022 is based on the input of more than 700 manufacturing companies across the globe. The results show that the most effective companies – we call them Digital Champions – are implementing a full suite of factory-level digital technologies to drive manufacturing flexibility and resilience, as well to reduce operational cost via factory automation.

Based on the survey results, only 10% of companies have fully implemented digital factory solutions or are currently in the final phase while almost two thirds of the companies can only show partial results or are even at the beginning of their digitization journey. In comparison to our first survey from 2016, factory digitalization is progressing much more slowly than companies expected at that time. The reasons include complex system environments and heterogeneous machine landscapes, and the associated challenges of scaling individual solutions across the entire production network.

The results of the survey also show that these digital operations solutions demand a fit-for-purpose IT and digital backbone to ensure interoperability and scalability to achieve the expected efficiency gains and savings. They are orchestrated by a standardized core IT architecture including integrated Enterprise Resource Planning (ERP), Manufacturing Execution Systems (MES) or Manufacturing Operations Management (MOM), the Industrial Internet-of-Things (IIoT) and digital Product Lifecycle Management (PLM).

While leading companies focus on a standardized core IT architecture combined with modern cloud services, they also build in considerable flexibility in the way embedded teams drive regional or business unit-specific implementations. These companies become a new kind of digital entity, an embedded digital organization, where management of systems, use cases, technologies and standards is centralized and rigorously controlled, but where execution is flexible enough to allow modular or partial solutions according to local need. For leading companies, digital transformation always takes place in a human setting: the transformation needs the right organizational set-up and employees need to be enabled for the digital transformation.
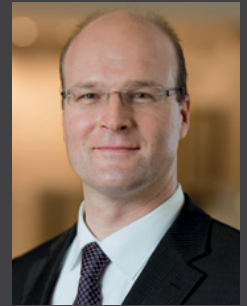
The survey also shows that companies that are willing to invest in the digital transformation journey enjoy higher returns. We find that on a global basis, industrial companies are investing $1.1 trillion a year in digital transformation solutions, and in return the most committed and advanced companies – the Digital Champions – are creating double-digit returns through a combination of cost efficiencies and higher operational flexibility.

This moment in time is likely to prove a once-in-an-era inflection point. Digital transformation needs to be based on a capable IT and data infrastructure with the right mix of applications and technologies in use – from integrating cobots or autonomous guided vehicles (AGVs) into the operations value chain to driving operations flexibility and resilience via digital planning tools. In addition, employees and other stakeholders need to be persuaded that the digital transformation is not a threat but a chance to develop personally, through providing the right skill mix to all employees.

The 2022 survey shows that in the face of an unprecedented time of crisis, digital transformation is the path of choice toward building operational flexibility and resilience while driving forward operational excellence.

Dr Reinhard Geissbauer
Partner,
PwC Germany

Michael Bruns
Partner,
PwC Germany

Jens Wunderlin
Senior Manager,
PwC Germany

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A Executive summary

Fig. 1   Executive summary/key findings

1. 64% of companies are still at the beginning of their digital factory transformation
Only 10% of globally surveyed manufacturers have completed their digital transformation programme or are currently in the final phase; 64% of the companies have only completed initial pilot installations or even less and need significant resources to complete their digital transformation journey. Now is the time to increase implementation efforts.

2. The transformation imperative has shifted from efficiency improvements towards flexibility and resilience
The COVID pandemic and conflict in Europe have forced leading manufacturers to implement digital solutions that drive higher production flexibility and better delivery resilience. The capability to deliver in the face of material scarcity and volatile supply chains are driving investments in operations resilience and factory automation.

3. Digitally enabled sustainability solutions have been gaining importance
Increasing legislation requirements, pressure from the capital markets and a global mindset shift are driving investments in sustainability. Digital solutions include CO_2-efficient transport and logistics systems, energy-efficient use of resources in manufacturing and the introduction of recyclable "fully circular" product solutions.

4. Over $1.1 trillion of annual investments in factory transformation – focus is on Asia and Europe
Global digital investments reach more than $1.1 trillion a year, with companies in industrial manufacturing and the chemicals industry spending the majority of digital funds. The investment focus is on Europe for labor cost arbitrage, and Asia for automating high quality production volume growth.

5. Only high investment leads to high returns – a solid foundation drives scalable digitization
One quarter of the surveyed companies, who spend at least 3% of net revenue on digitalization solutions, yield the highest, double-digit returns and quick pay back on their investments. Factory transformation cannot be done half-heartedly, but needs a solid IT and data backbone with focused operations and automation applications.

■ Strategy and roadmap   ■ Investment focus

Source: PwC Digital Factory Transformation Survey 2022

10. Digital Champions evolve from a centralized to an embedded organizational set-up

Leading companies often develop into an embedded digital organization, with central management of systems, technologies and standards. They provide implementation flexibility to embedded teams based on the requirements of regions or business units for a fully-fledged or partial implementation across the company.

9. An agile target operating model to run the digital transformation is essential

Leading companies establish an agile target operating model to effectively develop and implement digital processes and solutions. This approach includes standardized connectivity of assets with best-in-class digital solutions, as well as a use case-based digital transformation approach.

8. Emerging technologies with relatively short-term payback include drones and 5G applications

Payback times for digital technologies average around 2.7 years. Faster ROIs of less than one year are most likely found for investments in drones or 5G applications. Surprisingly, investments in cobots or AGVs have the longest payback periods.

7. Quality analytics, maintenance solutions and automated KPI monitoring are the most implemented use cases

Successful implementation is key: almost half of surveyed companies have implemented effective digital maintenance solutions and 40% of the companies are using advanced quality analytics tools. Other technologies, like the digital product twin or digital lean solutions, are lagging behind.

6. A standardized digital backbone is the key building block for successful factory transformations

Digital champions build a comprehensive IT architecture with an integrated, standardized ERP and integrated core operations applications like MES/MOM, IIoT or PLM. Focus is on a standardized core IT architecture, with regional or divisional flexibility in implementing a subset of digital solutions in each factory.

■ Digital backbone, use cases and technologies   ■ Organisational setup
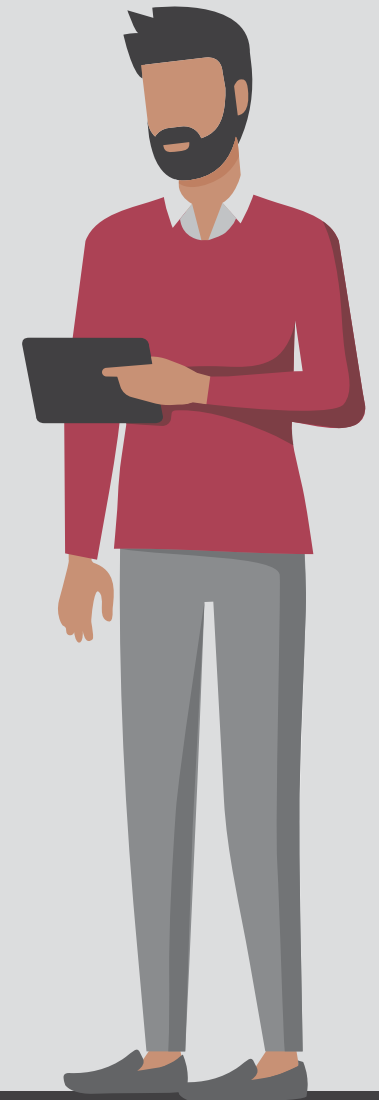
B Strategy and roadmap

Most companies are still at the beginning of their digital transformations and have not managed to scale their digital initiatives. Digitization is still high on the agenda, but the imperative has changed. Due to external disruptions, resilience and transparency are now the key drivers for the digital transformation while cost and efficiency are of lesser importance. Another driver that has been gaining importance and will continue to do so in the future is sustainability. Companies have realized that digitization is an important means to address their sustainability challenges.
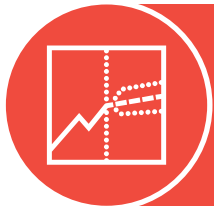
1. 64% of companies are still at the beginning of their digital factory transformation

Digital transformation is challenging. Back in 2014 when we conducted the first PwC Industry 4.0 Survey, the majority of companies told us that they were at the beginning of their digital transformation story, and 80% of those companies expected to have achieved a high degree of end-to-end digitization through the vertical value chain by 2019. Those optimistic expectations have not been fulfilled. Today, almost eight years later, 64% of companies in the PwC Digital Factory Transformation Survey 2022 are still close to the beginning of their digital transformation.

It is more than a decade since the concept of a digital "Industry 4.0" first emerged – and the leading question is, why is it taking so long for digital transformations to be completed? The current survey, supported by PwC's wider research and client experience, suggests that organization, skills, planning and enabling investment are all areas where companies now need to step up and match the success of companies identified as Digital Champions, 80% of which have largely or fully completed their transformation programs.

These are the issues that we believe are holding companies back. In the coming sections we will discuss each of them in detail, and provide a roadmap based on the experience of Digital Champions, to help companies clear obstacles and realize their digital transformation ambitions.

▶ Transformation needs the right organizational set-up, supporting an agile operating model and enhanced digital skills.

▶ Planning for transformation means building in scalability from day one.

▶ Key enablers such as the digital backbone, vertically and horizontally integrated, demand high investment.

▶ Systems, processes and connectivity need further standardization and harmonization to support enterprise-wide rollout.

> "To achieve transformation, you need to show courage. You need to set hard targets and act with speed. That is more effective than agonizing over concepts and overly-detailed ROI calculations."
>
> IT Leader, global high-tech and electronics group

Fig. 2   The long road to transformation

	Developing roadmap	Beginning transformation	Initial progress	50% complete	75% complete	Total transformation
All companies	2%	20%	42%	26%	7%	3%
Digital Champions	0%	0%	0%	19%	51%	29%

Road to the digital factory
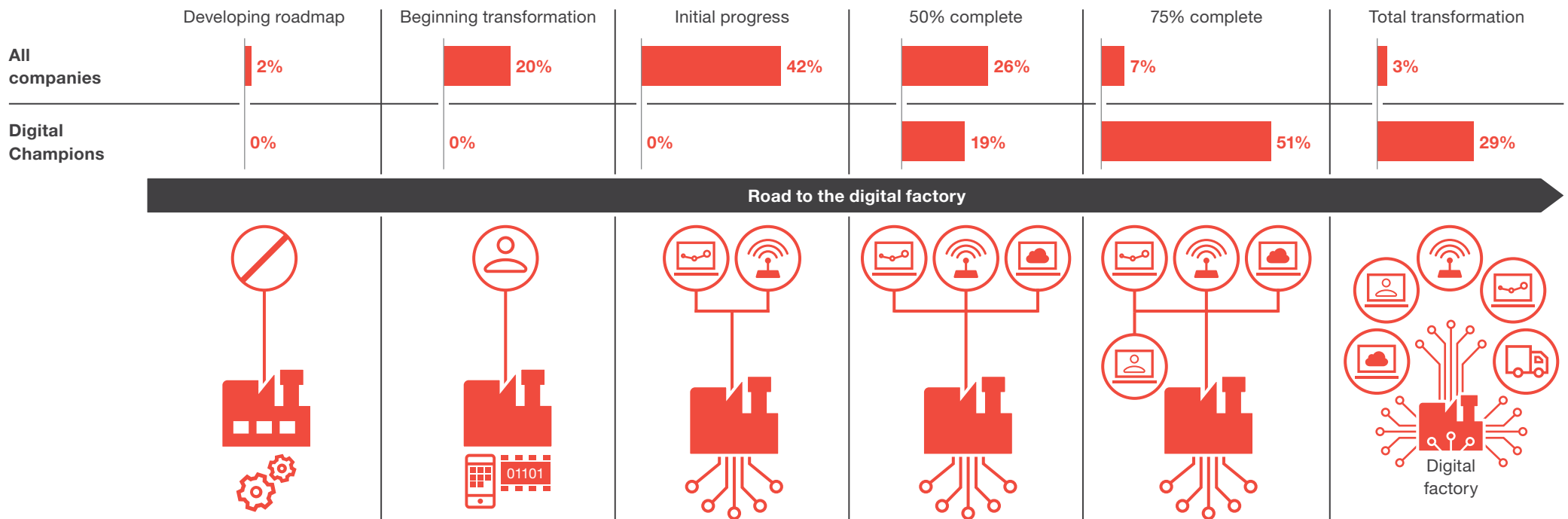
Digital factory

Source: PwC Digital Factory Transformation Survey 2022

2. The transformation imperative has shifted from efficiency improvements towards flexibility and resilience

Manufacturers are experiencing unprecedented levels of disruption. The supply and demand disruptions generated by the global pandemic have given way to shortages of materials and critical finished inputs, inflation and war in Europe. This has shifted the transformation imperative: cost leadership and efficiency improvement are no longer the primary strategic goals of digital leaders. In an era of unprecedented stress and uncertainty, digitization confers the flexibility and resilience that allow companies to prosper in the face of disruption.

The survey results show that in 2022 there has been a drop of more than 40% in the number of manufacturers citing cost and efficiency as leading drivers of digital transformation; resilience, flexibility and transparency have taken over as strategic priorities. One third of respondents now state that resilience and transparency are the main drivers of their digital factory transformation. Sustainability has also risen up the manufacturing agenda, with the number of respondents citing sustainability as a digital transformation driver more than doubling.

In an era of disruption, speed is of the essence. Faced with broken supply chains, volatile prices and geo-political storms, companies need to build their capacity for rapid response. Manufacturers recognize that digital transformation offers multiple routes to improving adaptability at speed. This means enhanced transparency with full operational visibility in real time is becoming a core capability; reacting quickly and effectively to disruptions is only possible when companies understand the underlying causes of business disruption within their own value chains. It means enhanced flexibility in systems, processes and asset deployment, allowing companies to adapt products and shift operations within their manufacturing network. Companies also need to be able to make data-driven decisions on what to produce next, within the current constraints, to serve customers best while managing cost, inventories, etc. This needs to be supported by the standardization of systems, technologies and processes to make all the necessary adaptations seamless, rapid, efficient and effective.
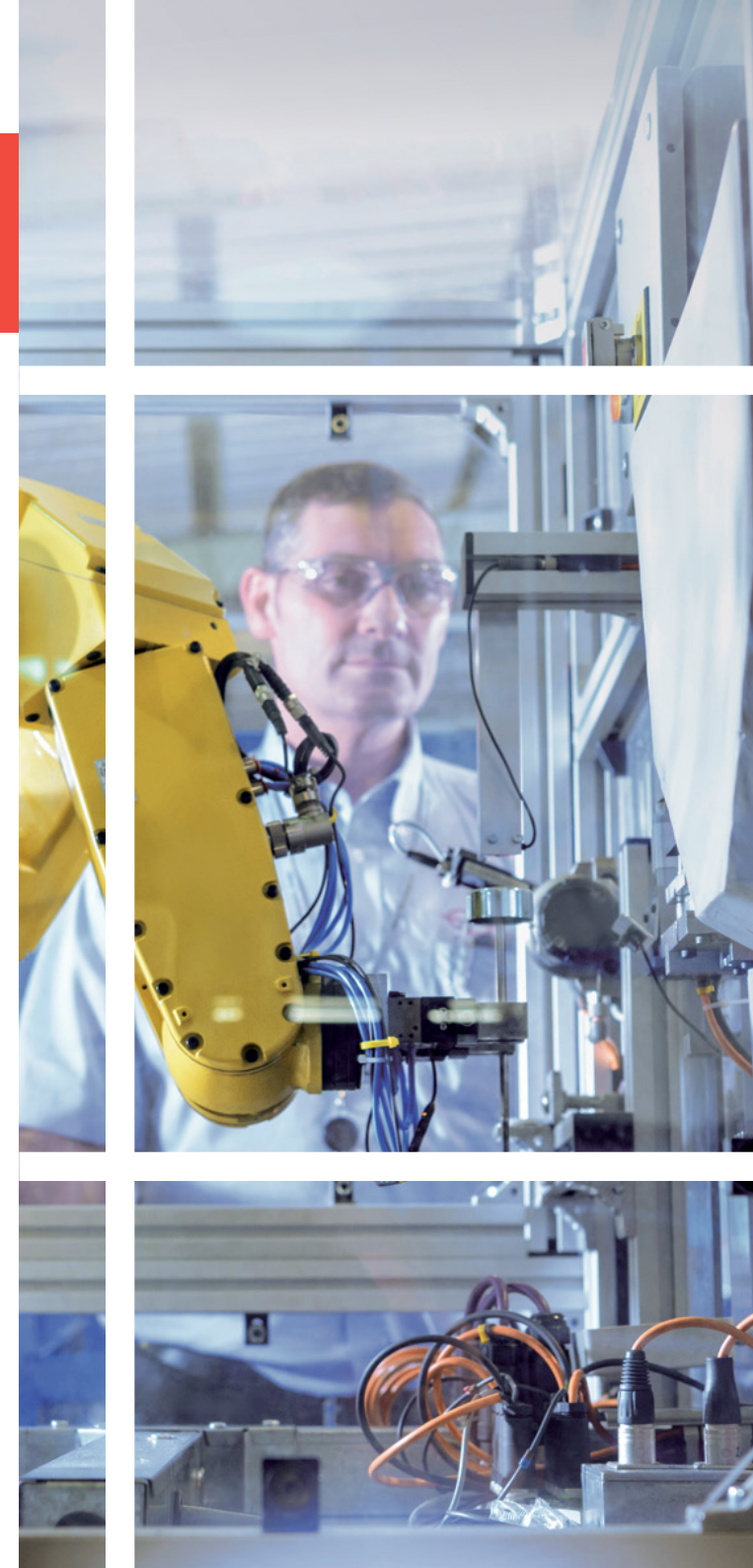
Fig. 3   New priorities: resilience, flexibility and transparency

−42%
46%
27%

+67%
20%
34%

+148%
4%
10%

+18%
8%
10%

+16%
10%
12%

−31%
11%
7%

Cost leadership and efficiency improvement

Resilience, flexibility and transparency

Sustainability leadership

Greater personalization and individualization

Greater innovation rate and faster time to market

Service leadership/ higher customer satisfaction

■ Recent trends   ■ Future trends
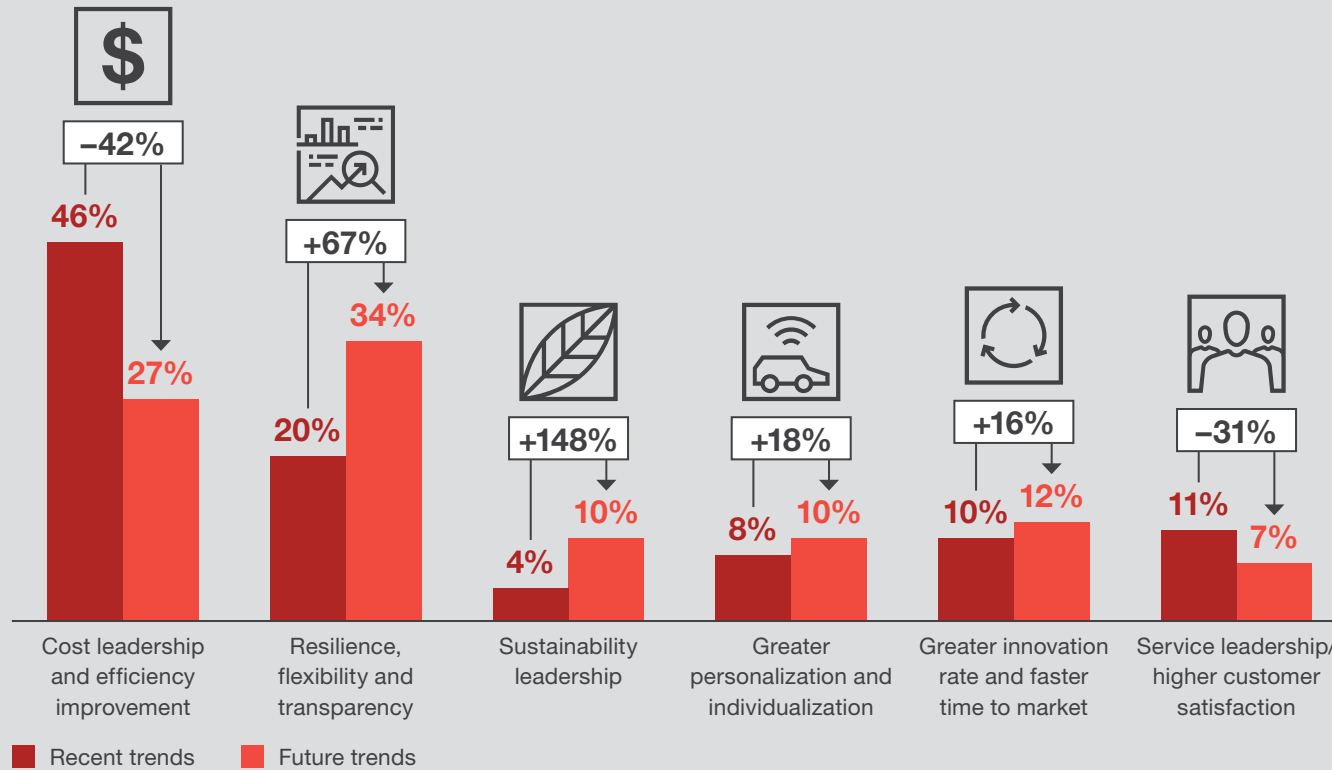
Source: PwC Digital Factory Transformation Survey 2022

"

Resilience is about preparing for the unexpected. You need to react quickly to mitigate external stresses, and that is what digital transformation is designed to enable."

Chief Digital Officer, global chemicals group
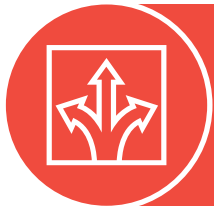
3. Digitally enabled sustainability solutions have been gaining importance

The PwC Digital Factory Transformation Survey 2022 shows that digitally enabled sustainability solutions are increasingly becoming a strategy of choice for companies. The increased attention paid to sustainability initiatives as part of the digital factory transformation process is visible globally and across all industries. Automotive and pharmaceutical companies are the most likely to have increased their investment in factory level sustainability, but all sectors evidence a significant increase in the sustainability component of their transformation strategies. The importance of sustainability as key driver for the digital transformation rose by 150% on average. For most companies, sustainability now has either equal or greater importance than strategic goals such as cost leadership and time to market.

Other PwC studies show that there are four important drivers behind this enhanced role for sustainability. Customer demand is increasingly significant: for example, the 25th PwC Global CEO Survey shows that most corporate net-zero commitments are customer-driven, and our 2021 Consumer Intelligence Series survey on ESG shows that 83% of consumers think companies should be actively shaping ESG best practices. Competition for talent is also driving sustainability adoption: our studies show that 86% of employees now prefer to work for firms that prioritize sustainability. Investment demand is strong: there is record demand for ESG-linked assets (with inflows to EU sustainable funds rising 18% year-on-year in the first quarter of 2021).

Finally, regulatory pressure is growing: the corporate path to net-zero carbon emissions is now a legislative reality in most large economies, with companies obliged to achieve carbon neutrality by 2050 or earlier. These targets impose reporting requirements that demand digitally-enabled transparency of operations throughout the value chain – for example, the EU Corporate Sustainability Reporting Directive expected to come into force in 2023 will impose detailed carbon reporting requirements on an estimated 49,000 companies, up from 11,600 under the existing Non-Financial Reporting Directive.

Fig. 4   All sectors increase digital sustainability focus

Growing importance of sustainability in digital factory transformation

Sector	Recent trends	Future trends	Change
Automotive and transportation	4%	14%	+266%
Pharma and medtech	4%	13%	+199%
Chemicals/ process industries	5%	11%	+138%
Retail and consumer goods	3%	10%	+189%
High-tech and electronics	5%	9%	+98%
Industrial manufacturing	4%	6%	+36%

■ Recent trends   ■ Future trends
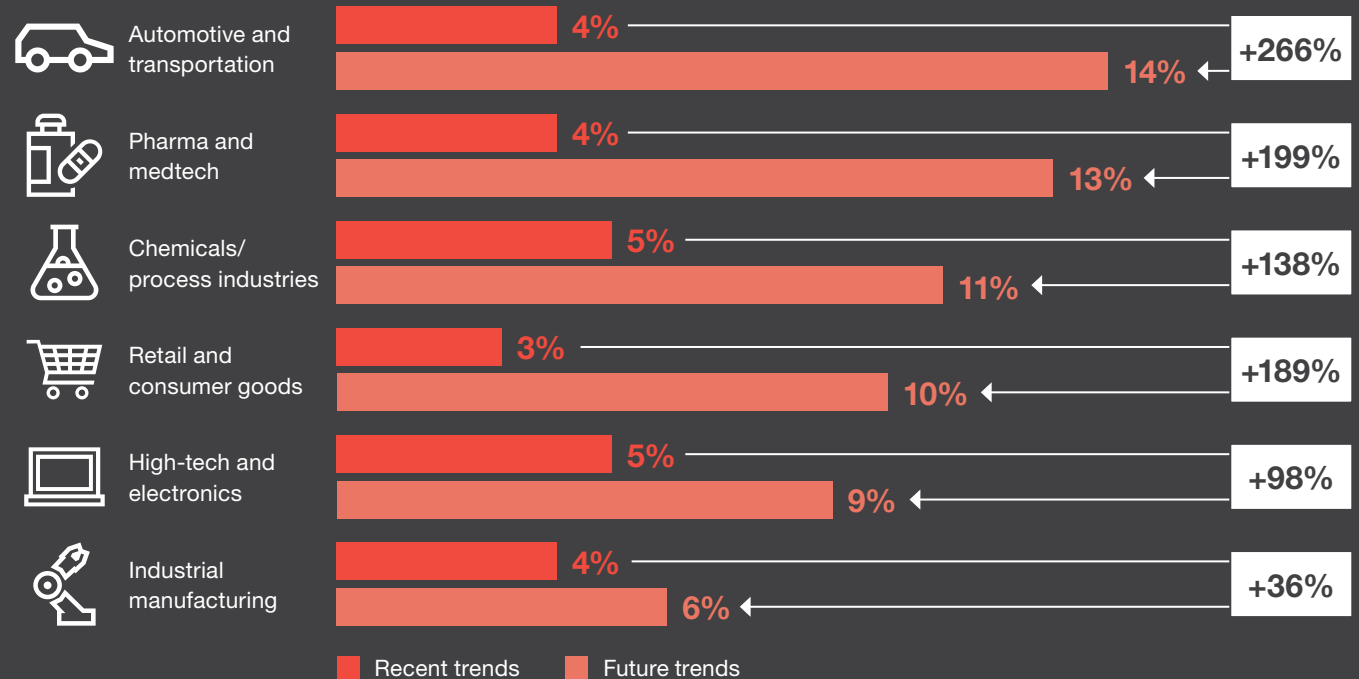
Source: PwC Digital Factory Transformation Survey 2022

Client experience tells us that current and future sustainability expectations and requirements can only be facilitated through a digitally led mix of technology solutions, the right processes and the right people skills through the entire supply chain. Digitization also provides an opportunity to not only meet external expectations and requirements related to sustainability. It provides companies with the tools to actively drive the change, reduce cost and gain competitive advantage.

The graphic below shows winning digital solutions that improve companies' sustainability. It encompasses suppliers and in-house production, through to service and recycling. In each segment of the value chain there are multiple digital solutions to improve sustainability.

Fig. 5   Digitally enabled sustainability has been vastly gaining importance

8

Employee transformation and sustainability KPIs
- Innovative sustainability communication, change management and training
- Objective, real-time sustainability KPIs and controlling

1

Product development and integrated engineering
- Design for sustainability, e.g. alternative materials, modular and low complexity products, energy efficient machines and processes and production sites

2

Connected supply chain
- SC transparency/visibility
- SC segmentation (combine SLAs with sustainability targets)
- Circular supply chain (closed loop)
- Advanced forecasting for planning stability – green value chain

7

Technology enablement
- E2E data strategy and data management
- IIoT solutions and platforms
- Artificial intelligence
- E2E connectivity

Design **1** Engineer **2** Plan

8 Employee transformation and sustainability measurement

7

Technology enablement **6** Service, return, recycle **5** Deliver **4** Make **3** Source

3

Supplier network management
- Automated sustainability/ESG monitoring
- Regionalizing and adjustment of supplier network
- ESG emission scores in supplier evaluation
- Make vs. buy (include ESG scores)

6

Intelligent service, second life solutions and recycling
- Remote service
- AI-based service planning
- Sustainable waste and second life management

5

Efficient transport management
- Lower emission modes of transport, packaging formats
- Sustainable transport SLAs agreements
- Eco-friendly means of transportation

4

Smart manufacturing
- Automatic sustainability monitoring and forecasting
- Automated, standardized reporting
- Sustainability performance analytics and lean management
- Regionalizing the footprint
- Renewable energy and recycling

Source: PwC Digital Factory Transformation Survey 2022

> "
>
> Sustainability is no longer merely 'nice to have' – it is simply essential to survival. That's because customers, employees, investors, governments and society now judge companies by how their business activities influence the environment and society."

Daniela Geretshuber,
Partner, PwC Germany

Siemens

Siemens tracks carbon emissions throughout the supply chain. Digital solutions help customers accurately measure and securely share data on total product carbon footprint (PCF).

Siemens is a technology company focused on automation and digitalisation in industry, infrastructure for buildings, decentralised energy systems, mobility solutions for rail and road, and medical technology. From more resource-efficient factories and resilient supply chains to cleaner and more comfortable transportation, as well as advanced healthcare, Siemens creates technology with purpose that adds value for customers. By combining the real and the digital worlds, Siemens empowers its customers to transform industries and markets. The Siemens group has 125 facilities in Germany and is represented in 190 countries, with around 293,000 employees worldwide.
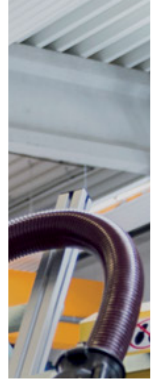
Decarbonising industry is a complex challenge, as the majority of emissions are generated in manufacturers' wider supply chains rather than by their in-house processes. This means that collaboration with suppliers, based on robust data, is key to reducing emissions. However, until recently there has been no accepted solution for accurately determining the total carbon footprint of a supply chain. It has been Siemens' mission to fill that gap.

As a leading technology provider in the field of automation and industrial software, Siemens is rolling out a product carbon footprint (PCF) solution that queries, calculates and shares the real-world total carbon footprint of products manufactured in complex supply chains. In order to reduce emissions, manufacturers need to know the location and intensity of all carbon-generating operations throughout their supply chains.

Siemens' PCF solution is a digital ecosystem-based approach to sharing emissions data. It has two elements: the first is SiGreen, a data acquisition tool that calculates actual emissions at multiple points from multiple suppliers, rather than estimates based on industry averages. These are so-called "Scope 3" emissions – emissions resulting

from activities or assets not owned or controlled by the reporting organisation. Having real data allows emissions to be accurately measured and controlled.

Yet for many companies, emissions data is also sensitive information, and data sharing requires rigorous and secure protocols. To ensure the security of data in the PCF solution, Siemens has also launched the cross-industry Estainium network to enable manufacturers, suppliers, customers and partners to exchange carbon footprint data without compromising their individual primary data sources. This is the second element of the PCF solution.

The Estainium network uses a decentralised distributed ledger data architecture, which means that any data generated via SiGreen can be verified as authentic without requiring disclosure of sensitive details of any one company's processes. Cryptographic certificates are created and exchanged to ensure trust in the information. In this way, the Estainium network provides trustworthy, aggregated carbon footprints across the entire supply chain, without any sensitive information being disclosed. Each party in the network retains full data sovereignty, as the data is not centrally stored.

This simplifies communication with supply chain partners and improves the calculation of all relevant emissions, significantly reducing the workload involved in calculating a total carbon footprint in real time. SiGreen also makes the carbon footprint of products fully traceable and enables manufacturers to take targeted reductions with immediate and quantifiable effects. This makes climate-neutral manufacturing and total sustainability in production into real possibilities.
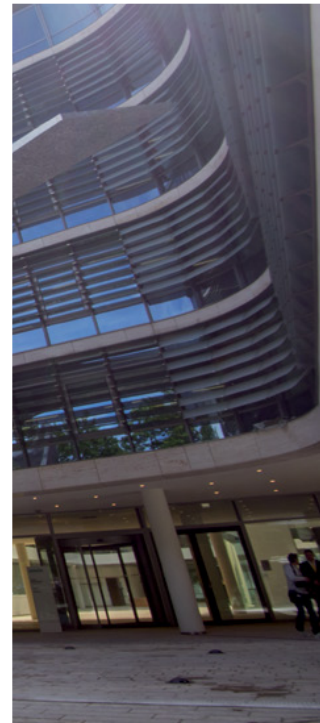
C Investment focus

We estimate that companies are investing more than $1.1 trillion a year in digital transformation, yet this may be insufficient. The evidence of our survey is that investment rates of at least 3% of net revenue (around 50% higher than the average corporate investment in transformation) are needed to deliver high returns and rapid payback on digital investment.

1. Over $1.1 trillion of annual investment in factory transformation – focus is on Asia and Europe

Manufacturers are investing heavily in digital transformation – yet the evidence from this survey is that the majority of companies are making only slow progress towards their transformation targets. Although companies from the six industry sectors represented in the survey group plan to invest at a rate equivalent to 1.8% of annual net revenues in coming years (representing a significant increase in capital commitment compared to recent PwC studies), some may need to raise their investment rates further, as this survey shows a strong correlation between higher investment and higher returns (see next section for details).

The current investment commitment is consistent across industries: the average investment range for all sectors is 1.6% to 1.9% of annual net revenues. Client companies tell us that the recent experience of working through the global pandemic has once more demonstrated that digital technology is now the response of choice to external operational stress.

Average digital transformation investment per annum:

1.8%
of net revenue

Fig. 6   Total investment by industry

Global transformation spend in six key industries

Grand total	Industrial manufacturing	Chemicals/ process industries	Retail and consumer goods	High-tech and electronics	Automotive and transportation	Pharma and medtech
$1,150bn	$318bn	$289bn	$214bn	$172bn	$112bn	$45bn
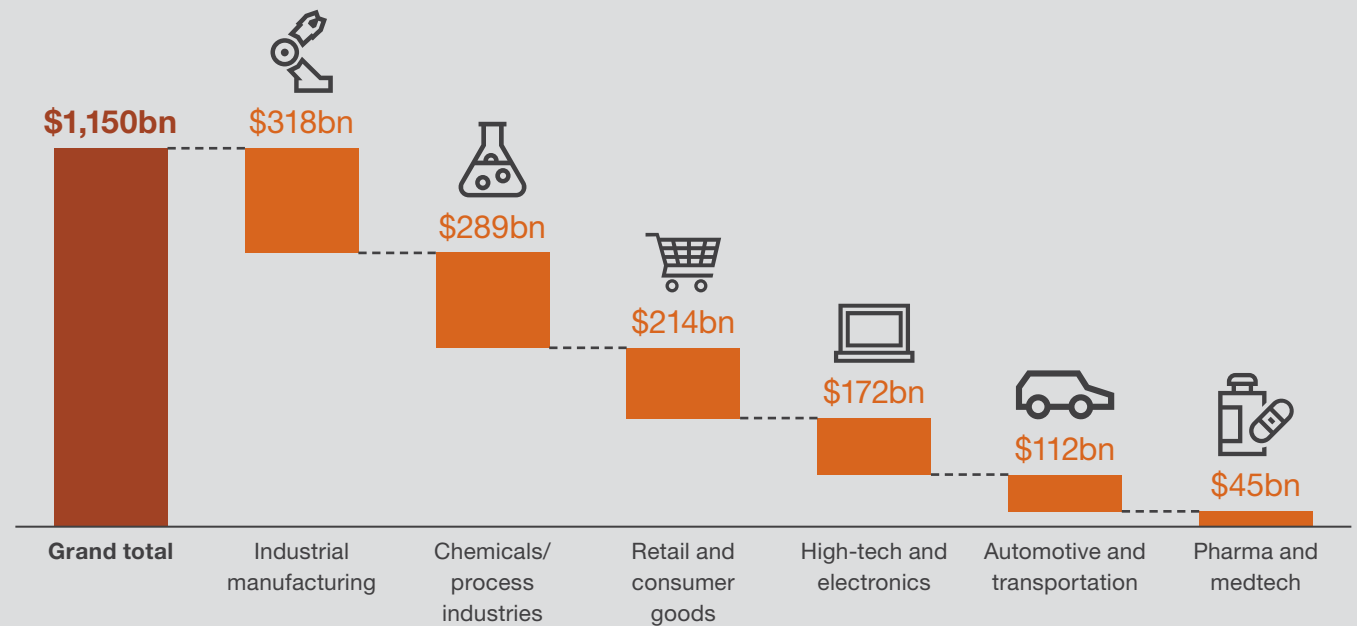
Sources: PwC Industry 4.0: Building The Digital Enterprise/PwC Digital Factory Transformation Survey 2022/IHS Markit

> **"The pandemic's worldwide impact is so great that almost overnight digital transformation has become essential to enterprises."**
>
> Chief Operating Officer,
> global chemicals group

Digital factory transformation is strongly regionally focused. Only 5% of companies participating in the PwC Digital Factory Transformation Survey 2022 drive their digital transformation programs globally – although high-performing companies are somewhat more likely to think globally, with 11.5% of Digital Champions rolling out global transformation programs.

The investment focus of the great majority of companies is in Europe and Asia-Pacific. A very high proportion of companies (87%) with manufacturing operations in Western and Central Europe are concentrating their transformation investments in those regions, while almost 70% of companies with operations in Asia are also investing in digital transformations in the Asia-Pacific region.

Fig. 7 **Transformation investment focuses on Europe and Asia**

Survey participants with at least one plant in the region[1]

| 372 | 335 | 82 | 201 | 103 | 42 |

Europe (West and Central)	Asia Pacific	Europe (Eastern)	North America	Latin America	Middle East/ Africa
13%	33%	43%	44%	50%	88%
87%	67%	57%	56%	50%	12%

■ Region of high investment focus   ■ Not a region of high investment focus
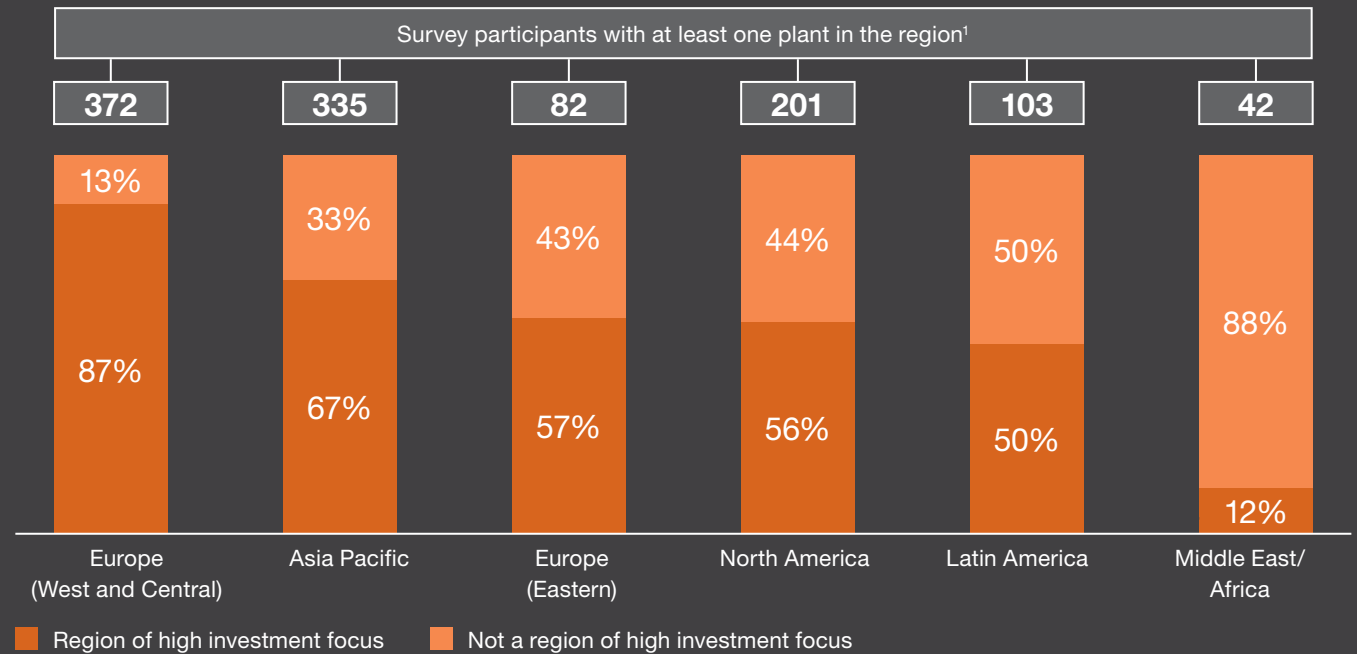
[1] Multiple choice possible.

Source: PwC Digital Factory Transformation Survey 2022

2. Only high investment leads to high returns – a solid foundation drives scalable digitization

The evidence of the PwC Digital Factory Transformation Survey 2022 is that high investment in foundational technologies such as the digital backbone and connectivity is required to enable the potential of applications throughout the manufacturing process.

Above-average investments are correlated with higher returns. According to the survey, companies that invest more than 3% of their net annual revenue in factory transformation are 2.5 times more likely to achieve high returns than those who invest less than 2%.

Fig. 8   The investment-return correlation

Digital transformation investment rate vs. returns

	High return	Moderate return	Low return	No/negligible return
Companies who invest up to 2% of their net revenue	10%	56%	30%	4%
Companies who invest 3% or more of their net revenue	25%	51%	22%	2%
Change	+153%	–10%	–24%	–56%

■ Companies who invest up to 2% of their net revenue   ■ Companies who invest 3% or more of their net revenue
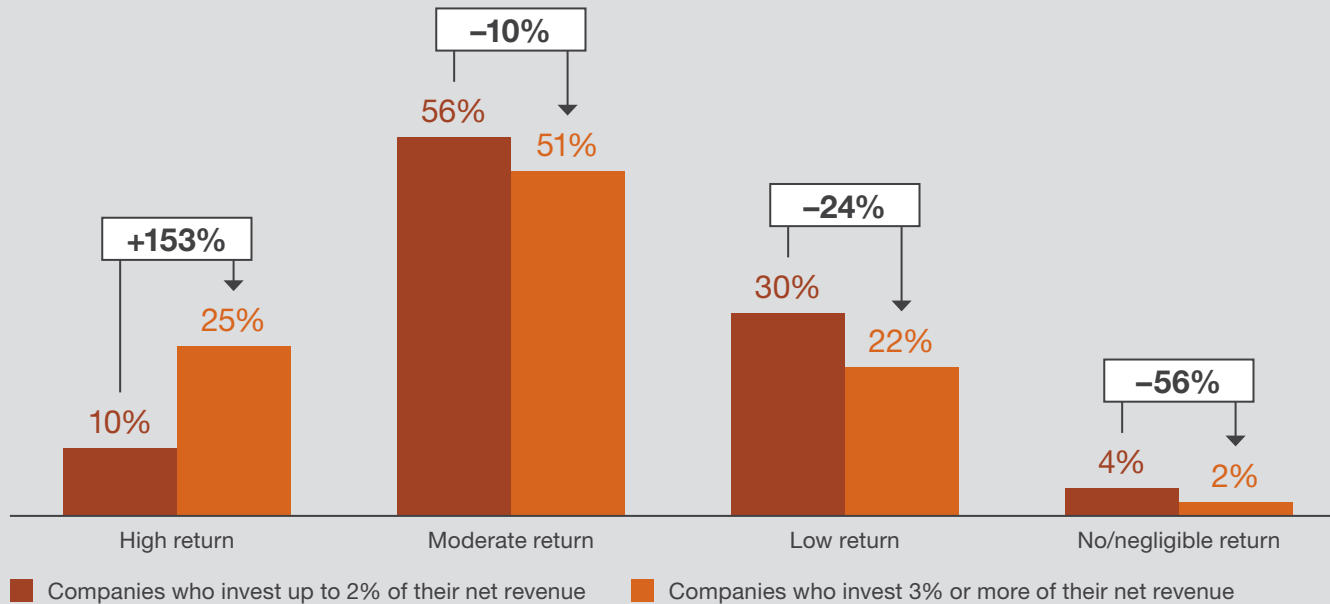
Source: PwC Digital Factory Transformation Survey 2022

When we analyze the survey responses in terms of system and use-case deployment mapped against returns on investment, it becomes clear that scalability is the critical factor that delivers high returns on digital investment.

In the graphic below, the x-axis depicts the number of use cases that have been deployed in digital transformation programmes and the y-axis depicts the number of systems within the digital backbone that are in use, while the red line shows return on investment. The data presentation shows that transformation programs that have achieved significant scale in terms of systems and use cases deliver exceptional returns. Significantly, it also shows that there appears to be an ideal level of scale: beyond a certain point, returns are not improved simply by adding more systems and implementing more use cases. Selecting the right technologies and extent of implementation is one key to optimizing returns.

This analysis confirms PwC's client experience, which shows that use cases require enablers such as shop floor data, line of business data drawn from the ERP, or systems within the digital backbone such as an IIoT platform. However, once solutions and services have been established for a set of use cases and technologies, further use cases can be added and implemented without major underlying enabling investments. Once companies understand the dependency between applications and underlying enablers, they can also determine the "sweet spot" where enabling investment allocation can best be matched to use cases, implementations and expected returns. This understanding is critical when it comes to formulating a digital transformation strategy, setting the transformation roadmap and calculating the value added through transformation.

Fig. 9   Scalability delivers high ROI

ROI vs. system and use case deployment

■ Number of systems deployed   —— ROI
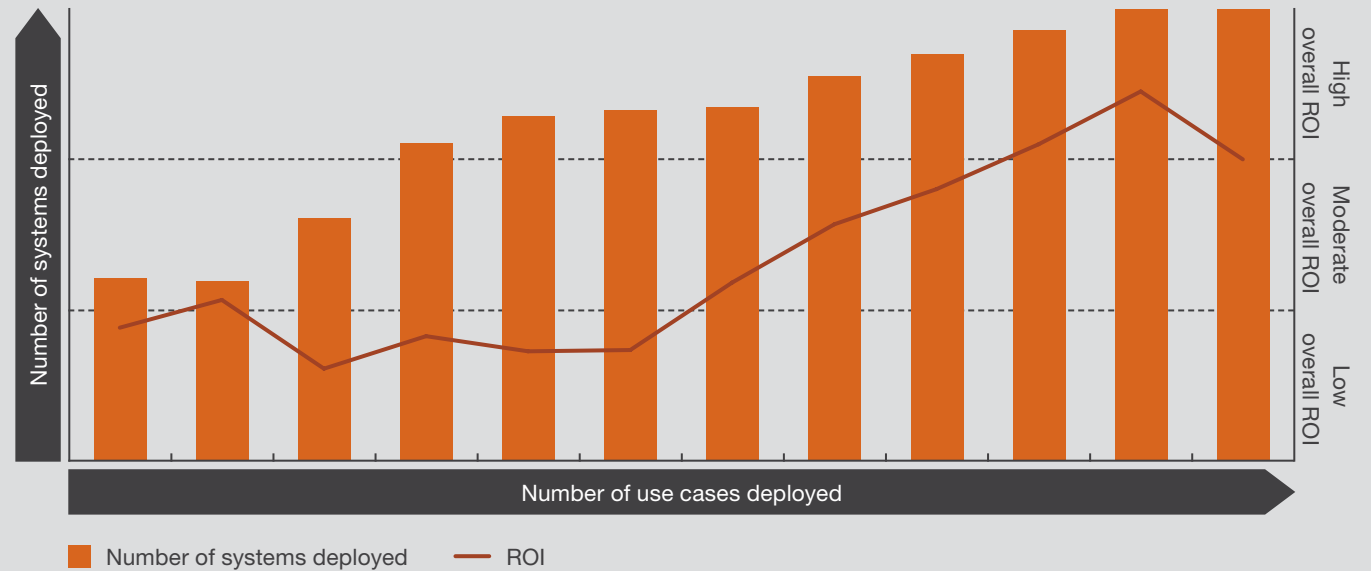
Source: PwC Digital Factory Transformation Survey 2022

> **"** Investment in advanced technologies should be seen as a core component of digitization, not as an add-on."

Chief Financial Officer,
industrial manufacturing group

D Digital backbone, use cases and technologies

Successful digital factory transformations are achieved through a complex interplay of systemic changes to the IT architecture, elaboration of business use cases and implementations of specific technologies. The digital backbone is the enabler of transformation, but there are multiple approaches to building or rebuilding this underlying architecture. Business use cases may range across quality, maintenance, monitoring or digital twin creation, while applied technologies can include devices, mobile applications, cobots and AI applications. While every transformation path is different, a common critical factor is the expected and actual payback period after initial or ongoing investment: although the PwC Digital Factory Transformation Survey 2022 shows that there is no one-size-fits-all strategy for digital transformation, the results of the survey show that certain systems and technologies tend to deliver faster payback, in some cases within as little as one year.
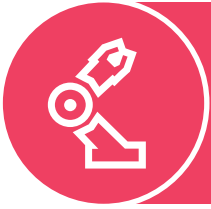
1. A standardized digital backbone is the key building block for successful factory transformations

The digital backbone of factories is critical to orchestrating and integrating all digital solutions within a factory and beyond. It mainly consists of one or more of the following four key solutions:

1 ERP – Enterprise Resource Planning solution

2 MES/MOM – Manufacturing Execution System/Manufacturing Operations Management solution

3 IIoT – Industrial Internet of Things platform

4 PLM – Product Lifecycle Management solution

The survey shows that integration is the foundation of outperformance: Digital Champions tend to use enabling systems that are more integrated and capable of greater standardization, even while allowing the various parts of their manufacturing networks a measure of freedom in how systems and supported technologies are implemented.

Fig. 10   Digital backbone archetypes and vendors

All-Stars (enlarged ERP play)

Manufacturing and Engineering Champion (MES – PLM play + IIoT)

CRM
IBP
WMS
ERP
PLM
MES/MOM
Mainten.
Quality
Inventory
SCADA/DCS
SPS and sensor level
IIoT
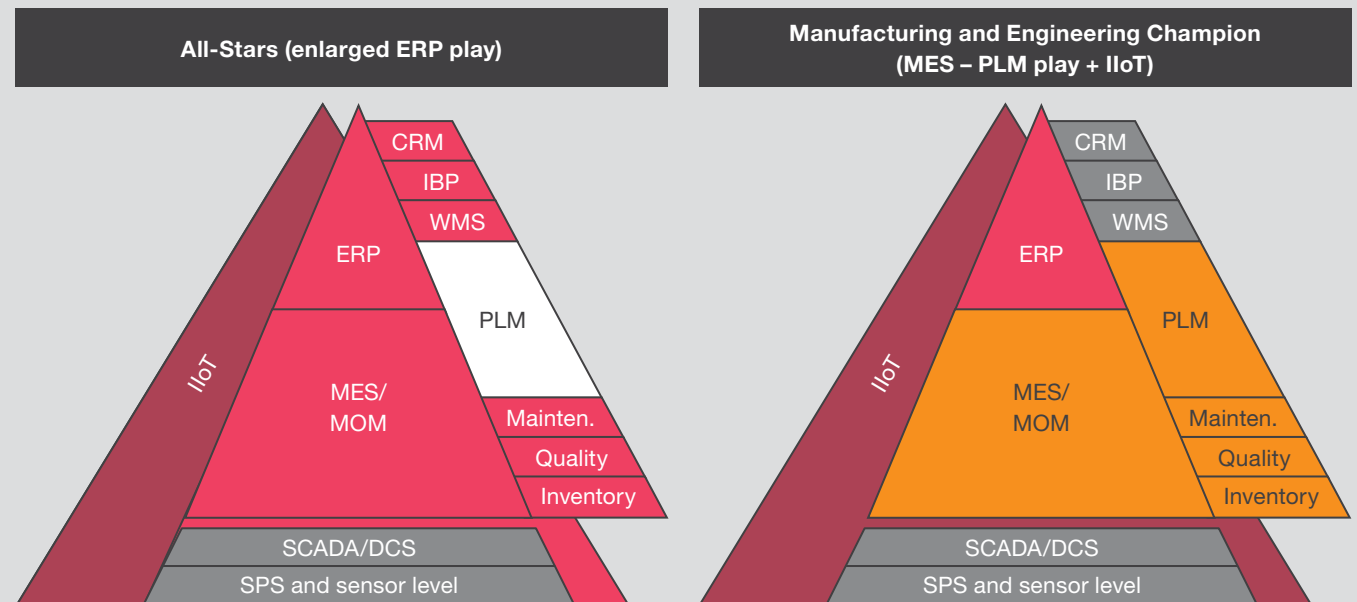
Same colors indicate typically same vendor

Source: PwC Digital Factory Transformation Survey 2022

The PwC Digital Factory Transformation Survey 2022 classifies companies according to five dominant digital backbone archetypes:

We identify All-Stars as companies with an ERP-focused backbone: they have implemented or are planning to implement a single enhanced ERP solution including at least two systems of differentiation such as PLM, MES and IIoT, all from the same provider as their ERP system. While 16% of companies participating in the survey are All-Stars, this is a preferred approach for Digital Champions and Innovators (34% of them use it).

Manufacturing and Engineering Champions focus their IT backbone on a solid PLM to drive effective R&D and engineering of their often highly customized and technology-driven products and services, with an integrated MES and in some cases an IIoT stack to augment the backbone. This is the most common architecture amongst all companies (25% use it), and it is also the preferred architecture for Digital Champions and Innovators (38% use it).

The Innovation Leapfrogger attempts to cut out costly and time-intensive MES/MOM implementations and concentrates on building out an IIoT architecture as the primary enabling system, with underlying use cases and with optionally integrated PLM solutions. This is an innovative backbone approach used by a minority of manufacturers comfortable with building their own applications; only 9% of all companies plan or have implemented this architecture, and only 3% of Digital Champions and Innovators.

The Customer Driver sees customer relationships as the primary value focus and relies entirely on an advanced ERP to ensure maximum customer coverage through Customer Relationship Management (CRM) modules in the ERP. Some manufacturing may be outsourced to partners. This model is planned or implemented by 15% of all companies, but by no Digital Champions.

Lastly it should be noted that a minority of companies have neither planned nor implemented any digital backbone archetype; we characterize this group as Explorers. This is a not-insignificant minority of all companies (18%) showing that it is possible, albeit rare, to embark on digitization without a planned digital backbone, but by using ad hoc solutions for individual digital technologies instead.

Fig. 11   Five system archetypes

Archetypes	MES	IIoT	PLM	Single enhanced ERP	All companies	Digital Champions and Innovators
All-Stars – ERP play	+	+	+	+	16%	34%
Manufacturing and Engineering Champion	+	(+)	+		25%	38%
Innovation Leapfrogger		+	(+)		9%	3%
Customer Driver				+	15%	0%
Explorer					18%	4%
Other archetypes					18%	20%

+ = Focus solution

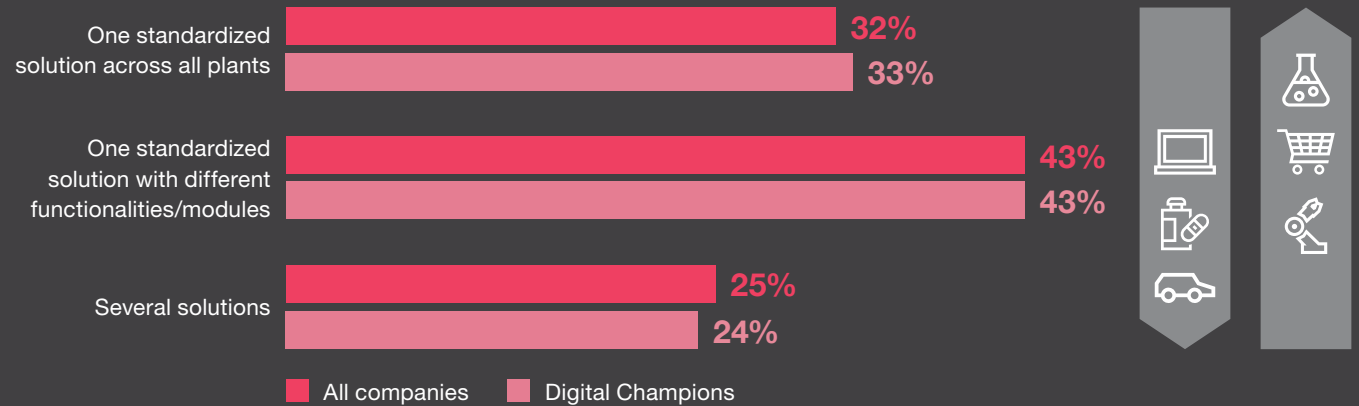Source: PwC Digital Factory Transformation Survey 2022

The results of the PwC Digital Factory Transformation Survey 2022 show that most manufacturers adopt a rich core of enabling IT systems, opting either for an ERP-focused solution or a PLM/MES-driven approach, but in both cases integrating systems from one or more external providers with the emphasis on coherence. These are related approaches and are the solutions that companies are most likely to adopt (72% of the Digital Champions and Innovators are either All-Stars or Manufacturing and Engineering Champions). By contrast, Innovation Leapfroggers concentrate on enabling high-frequency innovation: they do not consider they need holistic MES solutions or enlarged ERP systems, including systems of differentiation, but rather seek to leapfrog the stages of the digital transformation process using the capability of IIoT platforms. For Customer Drivers, the customer is the source of innovation, and an ERP-driven relationship management approach rather than an R&D-and-manufacturing PLM-supported approach is the architecture of choice.

The survey also shows clear patterns in the design of the IT backbone: operational complexity begets IT system complexity, and in turn creates a need for standardization. The higher the production complexity and horizontal scope of a company, the more it is likely to rely on several platforms that are more tailored to the needs of individual plants. Yet whether operations are relatively complex or relatively simple, companies prefer to adopt solutions capable of standardization to reduce cost and simplify implementation: while 32% of all companies opt for systems that are standardized throughout, a slightly greater number (43%) seek to balance standardization with a measure of implementation flexibility at plant level. There is no significant difference between Digital Champions and other companies in terms of the degree of standardization they adopt.

Fig. 12   Digital backbone target state

Digital backbone target state for MES and IIoT systems

Trend

One standardized solution across all plants
- All companies: 32%
- Digital Champions: 33%

One standardized solution with different functionalities/modules
- All companies: 43%
- Digital Champions: 43%

Several solutions
- All companies: 25%
- Digital Champions: 24%

■ All companies   ■ Digital Champions

Source: PwC Digital Factory Transformation Survey 2022

2. Quality analytics, maintenance solutions and automated KPI monitoring are the most implemented use cases

This section looks in detail at the survey responses on implementation rates in our three focus areas: the digital backbone, use cases and technologies.

2.1 Digital backbone implementation

The PwC Digital Factory Transformation Survey 2022 asked companies about the current state of their digital backbone implementations. While the survey shows that almost half of manufacturers still have not fully implemented a MES and more than half have not fully implemented either a PLM, IIoT or low code automation system, it also shows that such foundational IT backbone systems are in the process of being implemented everywhere. All companies participating in the survey have either implemented or are in the process of implementing at least one enabling IT system.

Fig. 13 **Digital backbone implementation status**

Implementation stage for selected IT solutions and their implementation share for selected industries

	Industry full implementation status		
	Industrial manufacturing	Chemicals/process industries	High-tech and electronics
Manufacturing Execution System (MES) 53% Implemented / 32% In rollout / 14% Piloted	55%	58%	58%
Product Lifecycle Management solution (PLM) 46% / 36% / 18%	52%	52%	44%
Industrial Internet of Things platform (IIoT) 31% / 41% / 23% / 6%	41%	28%	20%
Low code automation 10% / 43% / 40% / 7%	13%	13%	10%

Legend:
- Implemented
- In rollout
- Piloted
- Unplanned

Low — Medium — High
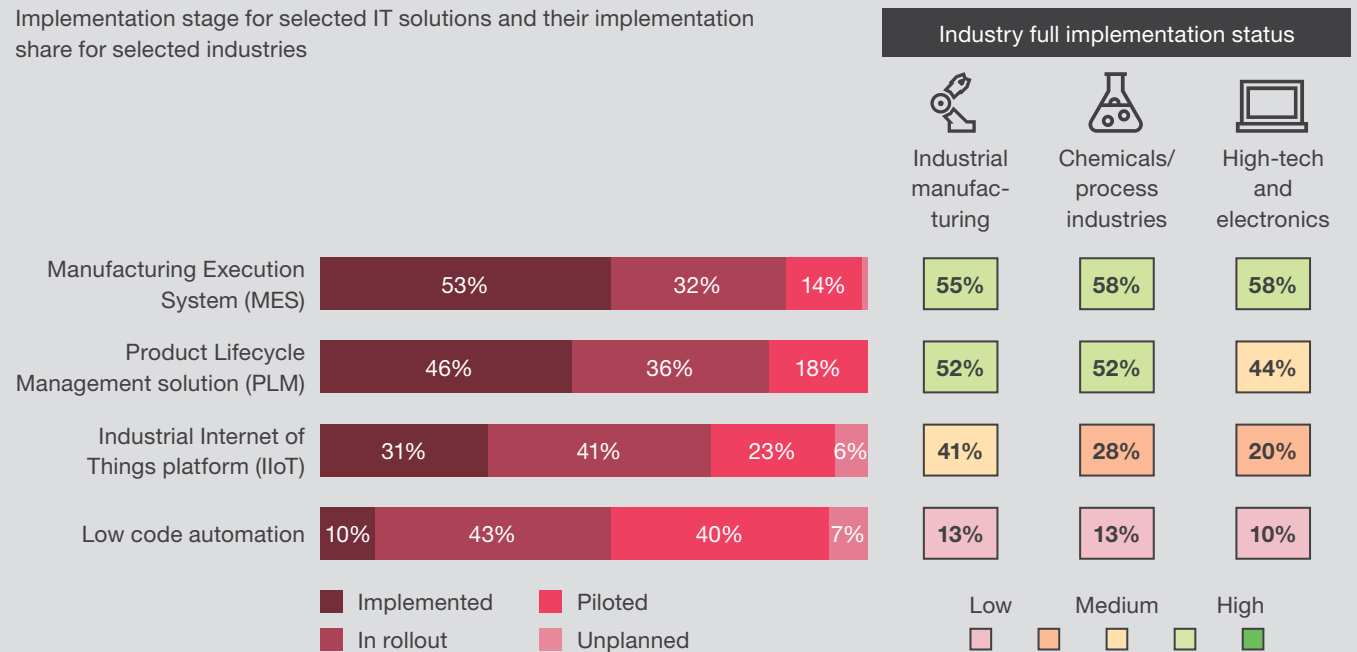
Source: PwC Digital Factory Transformation Survey 2022

Just over half of companies have fully implemented an MES/MOM solution, but the survey results suggest that implementation is now accelerating; the near future will see either MES/MOM or PLM solutions, or both, as universal features of large-scale manufacturing.

Although MES/MOM solutions have been available for decades (the concept and terminology were introduced by the Manufacturing Enterprise Solutions Association in 1992), only 53% of the surveyed companies have fully implemented an MES. This is now changing: MES solutions have evolved into MOM (Manufacturing Operations Management) solutions, covering the full spectrum of operations management (including production, maintenance, inventory and quality operations management) in one solution. In addition, MES applications are moving to the cloud and becoming more modular and interoperable with cloud platforms, allowing companies to select (and pay for) the specific features they need.

At the same time, ongoing ERP transformations are creating a natural opportunity for companies to review their digital backbone strategy. As a result, around a third of companies (32%) are now in the process of MES rollout and more (14%) have plans to do so.

IIoT is gaining traction as a system within the digital backbone, complementing traditional systems and breaking up the traditional automation pyramid. While only 31% of companies in the survey have implemented IIoT solutions today, 41% are in the rollout phase. The success stories of auto component manufacturer ZF show these solutions in action.

Companies are following two broad paths for IIoT implementation. They can go for the buy option, leveraging the existing platform solutions and use cases that are available on the market, requiring fewer internal resources but limiting the development of tailor-made solutions and market differentiation. Alternatively, they can pursue a make solution, building their own platform and solutions by leveraging the latest technologies and modules of large IIoT solution providers. The latter approach requires more internal resources but allows for greater freedom.

Comparing industries, industrial manufacturing companies are clearly leading on IIoT implementation; 41% of industrial manufacturing companies have already implemented IIoT Platforms. Chemicals and process companies and high-tech and electronics companies are lagging behind in this area (28% and 20% respectively have implemented IIoT).

We expect low code automation implementation to increase in the wake of IIoT and cloud adoption as it enables self-service application development and therefore is a key enabler for scaling of use case development. Currently only 10% of companies have completed low code automation implementation but 83% are in a rollout or piloting phase. Significantly, the most likely adopters of low code automation are Digital Champions, 26% of which have implemented this enabling technology.

"
Integrating our global operations with the help of MES and ERP assists in providing a clear view of the processes in real time."

Quality Management Leader, global automotive group
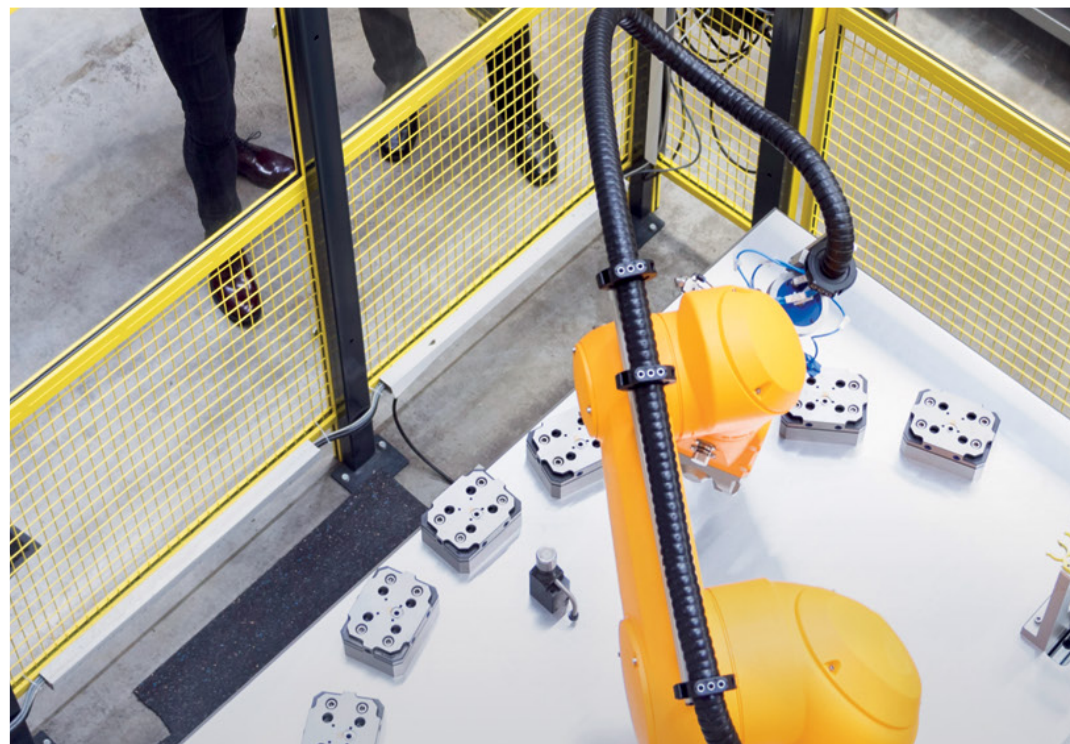
ZF Group

How ZF is transitioning to global digital operations. Tech company targeting multimillion-dollar savings by 2025.

As one of the largest Tier 1 automotive suppliers in the world, ZF supplies systems for passenger cars, commercial vehicles and industrial technology, enabling the next generation of mobility. ZF allows vehicles to see, think and act. In the technology domains of vehicle motion control, integrated safety, automated driving, and electric mobility, ZF offers comprehensive products and software solutions for established vehicle manufacturers and newly emerging transport and mobility service providers. ZF is electrifying a wide range of vehicle types. The company's products contribute to reducing emissions, protecting the climate and enhancing safe mobility. With some 157,500 employees worldwide, ZF reported sales of €38.3 billion in the 2021 fiscal year. The company operates 188 production facilities in 31 countries.

In 2020, ZF embarked on a mission to reduce controllable factory costs by integrating industrial internet of things (IIoT) solutions to improve quality and efficiency, and to increase its global manufacturing output. The company turned to PwC and Microsoft to build a scalable digital manufacturing platform (DMP) to drive digitalisation at 188 production sites across the world.

The first phase of the digitalisation programme called for an initial pilot project at the company's plant in Diepholz in northern Germany. This created an IIoT platform with common services and business applications, leveraging PwC Factory Intelligence and Microsoft Azure technologies.

The project followed three guiding principles. Firstly, the platform and enabling services needed to be built for scale. Secondly, the business solutions built on the platform needed to be relevant for most of ZF's plants, making them scalable too. Finally, the solutions needed to be useable by plants that were at less advanced stages in their digital transformation. Business applications and use cases were organised around three focus areas: the production control tower, end-to-end traceability, and maintenance intelligence.

Diepholz was selected as the first pilot plant because ZF's Car Chassis Technology Division had a well-established digital organisation that was capable of supporting the transformation. The team at the plant was also highly motivated to be front runners for the programme. Diepholz already had advanced levels of connectivity in place, and implementing the DMP offered considerable commercial potential.

The first focus of the project was transforming production to create better visibility into performance by developing automated KPI monitoring solutions and performance analytics use cases. Having these in place allows ZF to monitor performance and respond in real time.

The second focus was on end-to-end traceability that would allow ZF to quickly and easily trace a single product and/or batch through the entire production process. This helps the company to more accurately pinpoint where errors have occurred.

The third focus was on monitoring the condition of manufacturing assets in order to maximise uptime and optimise maintenance costs.

The DMP integrates data drawn from multiple sources, from machine level up to data from corporate enterprise resource planning (ERP) systems.

To develop the DMP, the company adopted an agile delivery and governance model, turning a traditional IT organisation into a product-centric agile one. All project members and plant experts worked on the basis of product increments (PIs) of three-month rolling planning phases and weekly sprints, allowing for regular reviews, alignment of responsibilities between the teams, and adjustments as implementation proceeded and the new target operating model was established.

Having proven the DMP's value at the Diepholz plant, the platform is now the cornerstone and key enabler for a multi-year digital strategy throughout ZF's global manufacturing operations.

However, the platform is not being rolled out to other plants in a conventional way. In the past, dedicated teams went from plant to plant to implement software solutions such as the manufacturing execution system (MES), but factories now need to be able to onboard independently and adhere to the DMP standards for themselves. The DMP organisation works with them during this process, providing standards, guidelines, checklists and support.

This approach to onboarding is simpler and allows a smaller workforce, and the ambition is to onboard each new plant to the platform within one week.

ZF is also seeking to broaden the functionality of the digital platform by enabling teams outside of the DMP to develop solutions on it. This will increase the number of use cases that can be made available for all plants, as well as giving plants the freedom to develop solutions that are specific to their needs.

When fully deployed across all ZF factories, the DMP is expected to produce annual cost savings of several hundred million dollars.

The solutions delivered at ZF have broad market potential for adoption across all manufacturing industries. The DMP provides a blueprint and best practice to drive digital transformation for automotive production and the Open Manufacturing Platform community as a whole, and the lessons learned at ZF can be used to accelerate any large-scale, smart factory transformation.
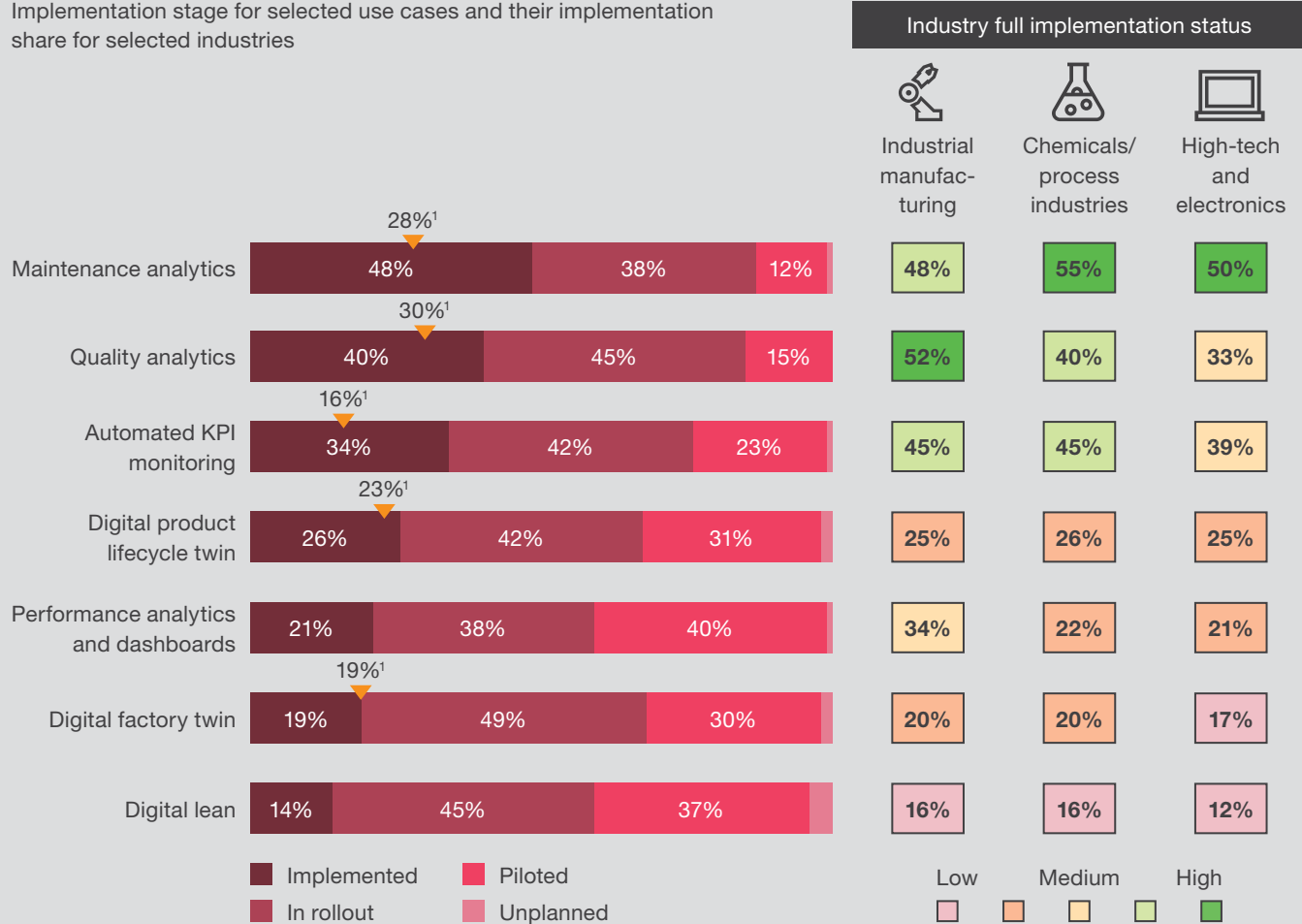
2.2 Use case implementation

In the four years since the 2017 PwC Digital Factory Survey, the implementation rate of use cases has risen – in some cases doubling. The most implemented use cases today are maintenance and quality analytics, and automated KPI monitoring. For example, more than half of companies in the chemicals and high-tech sectors have fully implemented maintenance analytics solutions to enhance efficiency and safety in production processes, and most companies that have not yet fully implemented maintenance analytics and quality analytics are currently in the rollout phase. The PwC Digital Factory Transformation Survey 2022 shows that companies in industrial manufacturing are the most likely to have implemented use cases.

The survey results indicate a high degree of consensus among companies on use case implementation. Almost all companies have either implemented or are rolling out maintenance analytics and quality analytics, and the number of companies with no plans to implement these use cases is negligible. The reported implementation rates represent a significant advance on the progress reported in the 2017 Digital Factory Survey. The area of greatest change is maintenance analytics, where companies have increased the implementation rate by 20 percentage points in the last five years.

In the case of quality analytics, the shorter payback period is an important driver of early implementation (see below for more detail); in the case of maintenance analytics there is a longer payback timescale, but companies clearly recognize that digital maintenance solutions are critical to reducing operational cost by cutting machine downtime. The third widely implemented use case is automated KPI monitoring, where 76% of companies have either implemented the solution or are rolling it out, and a negligible number have no plans to pilot or implement. Although performance analytics and dashboards, as well as digital lean, have lower rates of completed implementation, we expect that these implementations will follow from the completion of KPI monitoring, as they are logical extensions that build on the automation of KPIs.

Fig. 14   Use case implementation status

Implementation stage for selected use cases and their implementation share for selected industries

Industry full implementation status		
Industrial manufac-turing	Chemicals/process industries	High-tech and electronics

Use case	Implemented	In rollout	Piloted	Industrial manufacturing	Chemicals/process industries	High-tech and electronics
Maintenance analytics	48%	38%	12%	48%	55%	50%
Quality analytics	40%	45%	15%	52%	40%	33%
Automated KPI monitoring	34%	42%	23%	45%	45%	39%
Digital product lifecycle twin	26%	42%	31%	25%	26%	25%
Performance analytics and dashboards	21%	38%	40%	34%	22%	21%
Digital factory twin	19%	49%	30%	20%	20%	17%
Digital lean	14%	45%	37%	16%	16%	12%

Reference markers (PwC study of 2017): Maintenance analytics 28%[1], Quality analytics 30%[1], Automated KPI monitoring 16%[1], Digital product lifecycle twin 23%[1], Digital factory twin 19%[1]

Legend:
- Implemented
- In rollout
- Piloted
- Unplanned

Low — Medium — High

[1] PwC study of 2017: Digital Factories 2020 – Shaping the future of manufacturing.

Source: PwC Digital Factory Transformation Survey 2022
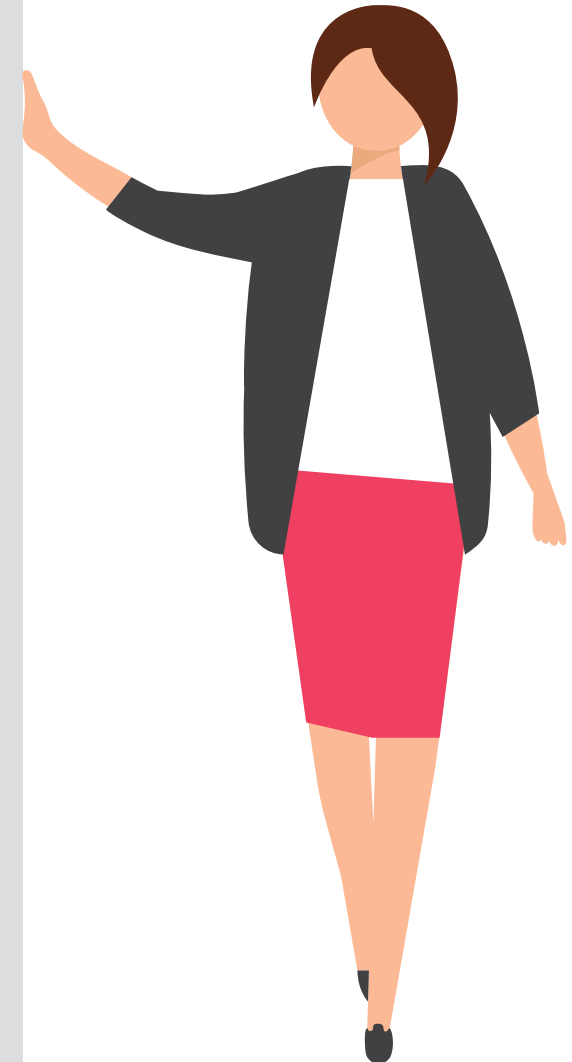
Yara

How Yara's innovative investment approach realised the company's full digital potential. Constant use case iteration and agile thinking were key to transformation, generating significantly increased EBITDA and major health and safety improvements in 2021

Yara is a leading global crop nutrition company, focussed on precision farming designed to make agriculture more efficient and sustainable. Headquartered in Oslo, Norway, with operations in more than 60 countries, around 17,000 employees and revenues of over $16 billion, Yara aims to use digital transformation of its own operations to help drive a green transition in crop nutrition.

Yara is a company that has been experimenting with digital operations for several years, but recently decided to accelerate the digital transformation process. Working together with PwC, Yara created a use case-driven programme that could be rapidly developed and implemented across a diversified global network of manufacturing facilities.

The challenge was to build up business investment cases for digital applications with a strong focus on end-user needs and experience, and to do this in a way that suited digital technologies and the digital mindset. Yara's digital transformation team began by selecting several areas that generally appeared to be a good fit, and then worked with the PwC team to connect use cases in those areas with the real world of factory floor operations.

"What we needed to do was focus not on technology first, but on value," says Jonathan de Ramaix, who led the project at PwC. "Right from the start, we needed to develop use cases from the point of view of real-world problems faced by production teams and by maintenance technicians, and then start to evaluate how much value (this could be monetary or related to health, safety, employee engagement and quality) each of the use cases could realise in individual plants."

To connect with the end user, the transformation team began by convening workshops with technicians to learn what kind of production problems they were facing, and what solutions to those problems would look like.

"You need to know what a day in the life of a maintenance technician looks like," says de Ramaix. "You need to know what all the key pain points are in the process. What kind of data will eliminate those pain points? If the data we have now is wrong, why is that and how do we change it? And then you can move on to building a simulation or a prototype solution which will give you an insight into what kind of impact the digital use case will have on individual sites. You can scope out what the impact would be on helping employees work safer, smarter and faster, on reliability and downtime, and on health, safety and environmental elements."

Doing this is the start of building a business use case, but only the start. Digital technologies offer a huge number of potential mixes of applications and impacts, some of which may not even have been thought of at the start of the use case process. This means that the process for making investment decisions needs to be equally flexible.

To do this, PwC and Yara used a process that blended agile thinking with venture capital-style budgeting for rapidly changing environments. If the situation changes, or the application does not work as expected, the use case can be changed, or even dropped altogether. Decisions are not irreversible: the decision gates work in both directions.

"This is very different from the traditional way of creating business cases for investment," says Jonathan de Ramaix. "This is much more like a venture capitalist approach. We see what works, we see what does not work. This is the nature of digital. If you want to actually realise your potential, you may need to be a lot more flexible than the kind of rigid investment-payback thinking that a lot of companies are used to. You may need to be prepared to have some failures and costs along the way, but in the end you will gain more."

The evidence is that the approach works. Solutions matched to user needs and behaviours tend to generate buy-in, and rapid return on investment. Yara estimated that the new digital use cases would have a double-digit impact in their first year of operation (2020), and more than double that in 2021.
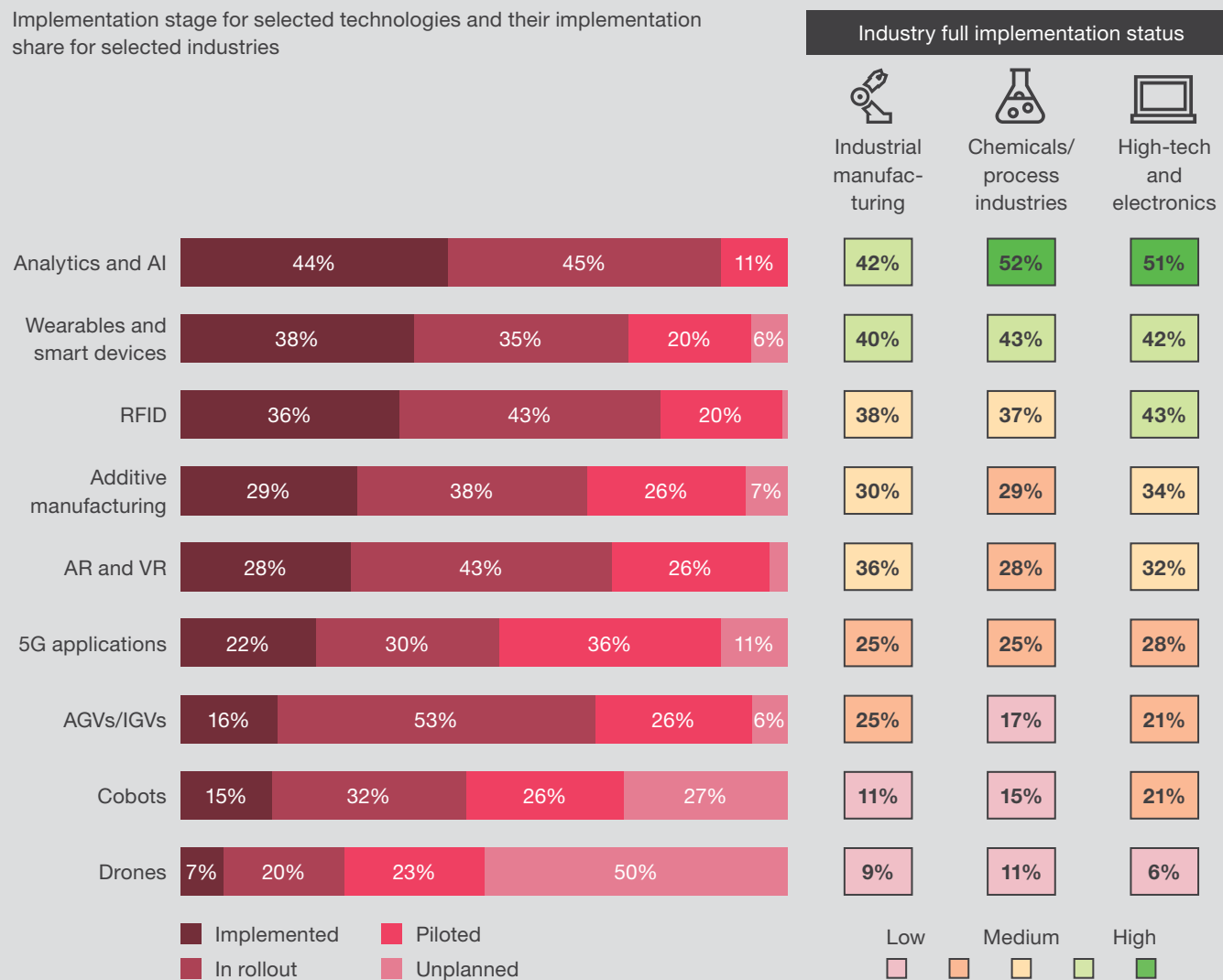
2.3 Technologies implementation

Technology implementations with analytics capabilities are top of the digital transformation agenda for manufacturers. Analytics and AI are the most implemented technologies: all companies in the PwC Digital Factory Transformation Survey 2022 have either implemented the technology or are in the process of implementation or piloting. In the foreseeable future, AI implementations will be universal.

Wearables and smart devices are also high on the agenda: 38% of companies have already implemented wearables, connecting the workforce in their factories. Only 6% of companies do not have plans to implement wearables or smart devices. The success story of Signify demonstrates the benefits of implementing wearables and smart devices (see below).

Yet in contrast to use case implementations, the payback timescale of technologies does not appear to be an important factor. Technologies with the shortest payback timescales such as drones and 5G applications are the least likely to have been implemented – for example a mere 7% of companies have implemented drones and only 20% are in rollout (unsurprisingly the chemicals and process industries are leaders in drone use, with 11% having implemented this technology with clear applications in remote and potentially dangerous operations). Client experience tells us that drones are niche technologies, and that implementing 5G applications is not the highest priority where Wi-Fi or wired networks are already in place and prioritized use cases do not benefit from low latency and high data bandwidth.

Fig. 15   Technology implementation status

Implementation stage for selected technologies and their implementation share for selected industries

Industry full implementation status

	Industrial manufac-turing	Chemicals/ process industries	High-tech and electronics
Analytics and AI	42%	52%	51%
Wearables and smart devices	40%	43%	42%
RFID	38%	37%	43%
Additive manufacturing	30%	29%	34%
AR and VR	36%	28%	32%
5G applications	25%	25%	28%
AGVs/IGVs	25%	17%	21%
Cobots	11%	15%	21%
Drones	9%	11%	6%

Bar chart values:
- Analytics and AI: Implemented 44%, In rollout 45%, Piloted 11%
- Wearables and smart devices: Implemented 38%, In rollout 35%, Piloted 20%, Unplanned 6%
- RFID: Implemented 36%, In rollout 43%, Piloted 20%
- Additive manufacturing: Implemented 29%, In rollout 38%, Piloted 26%, Unplanned 7%
- AR and VR: Implemented 28%, In rollout 43%, Piloted 26%
- 5G applications: Implemented 22%, In rollout 30%, Piloted 36%, Unplanned 11%
- AGVs/IGVs: Implemented 16%, In rollout 53%, Piloted 26%, Unplanned 6%
- Cobots: Implemented 15%, In rollout 32%, Piloted 26%, Unplanned 27%
- Drones: Implemented 7%, In rollout 20%, Piloted 23%, Unplanned 50%

Legend: ■ Implemented ■ Piloted ■ In rollout ■ Unplanned

Low — Medium — High

Source: PwC Digital Factory Transformation Survey 2022

Signify

Using an ecosystem approach to innovate with Industry 4.0. Implementation starts with a real-world user issue, and relies on a central orchestrator to bring together all the strands of the ecosystem.

How should companies find, evaluate and implement new technologies in their digital transformation programmes? Digital transformation is often a process of experimentation and learning, where companies connect a variety of unfamiliar technologies to achieve specific business aims. One powerful way of achieving this is by using an ecosystem approach, as PwC has been doing together with companies at the Open Manufacturing Campus (OMC) in Turnhout, Belgium. Ecosystems are collaborative corporate networks in which manufacturers can harness skills and technologies from partners and put them to work in new ways.

The OMC is a former Philips manufacturing site, and is still home to Signify, formerly Philips Lighting. Headquartered in the Netherlands, the company produces a portfolio of consumer and industrial lighting products, with €6.9 billion in sales and more than 36,000 employees worldwide.

Together with PwC, Signify recently developed new digital inspection and maintenance applications for its high-intensity discharge (HID) lighting production lines, working with an ecosystem of manufacturers. To bring the companies and technologies together, and generate and evaluate new use cases, PwC took on the role of the ecosystem enabler, bringing together the strands of the solution.

"The key here is how do you know what is out there, what is state-of-the-art, what is possible," says Johan Van der Straeten of PwC Belgium. "I think that is something that a lot of manufacturers still struggle with. They know about their own technologies; but unless they have a dedicated digital hub that actively searches for new technologies, it is difficult to know what is out there and how to use it."

For example, Signify wanted to enable its technicians to carry out paperless inspections and maintenance, but also keep their hands free – so carrying a tablet around was not an option. The ecosystem's solution lay in wearable technology: digitally enabled smart glasses. These look a lot like ordinary reading glasses, but they also have a digital readout visible to the wearer, guiding the way through inspection routines and remedial actions.

Manufactured by industrial wearables specialist Iristick, headquartered in Antwerp, Belgium, the smart glasses include a voice activation function which allows users to log inspections and interventions as they are deployed, in real time.

Signify's ecosystem partners realised the technology could be enhanced by collaborating with another company that happened to have operations at the OMC. This was Luxexcel, the only manufacturer in the world that offers on-demand 3D printing of corrective lenses. This meant that technicians who need to wear regular glasses could also use the smart glasses.

A fourth company is also part of the ecosystem – Proceedix, which provides an IT platform that digitises work instructions and checklists, ready for the technicians to open and follow using their smart glasses.

This is a manufacturing ecosystem in action. "We really see PwC as the enabler who can bring projects to fruition," says Johan de Geyter, CEO of Iristick. "Their strength is in bringing all the parties to the table and connecting the different dots to create real benefit for all stakeholders, from a usability perspective and the other elements that are crucial to the success of a project."
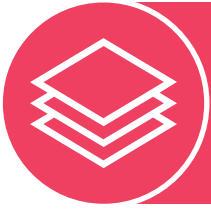
This section looks in detail at the survey responses on payback timescales for the digital backbone, use cases and technologies.

3.1 Digital backbone payback

The survey results show that of all the enabling IT architecture approaches, PLM solutions have the shortest average payback period. Some 59% of companies achieve or expect a payback in less than three years. Formerly considered to be solely a product development solution, PLM systems are nowadays fully integrated with production systems such as MES. Fully integrated PLM solutions facilitate the creation of digital twins or advanced manufacturing simulations and therefore add value not only for product development but also for production.
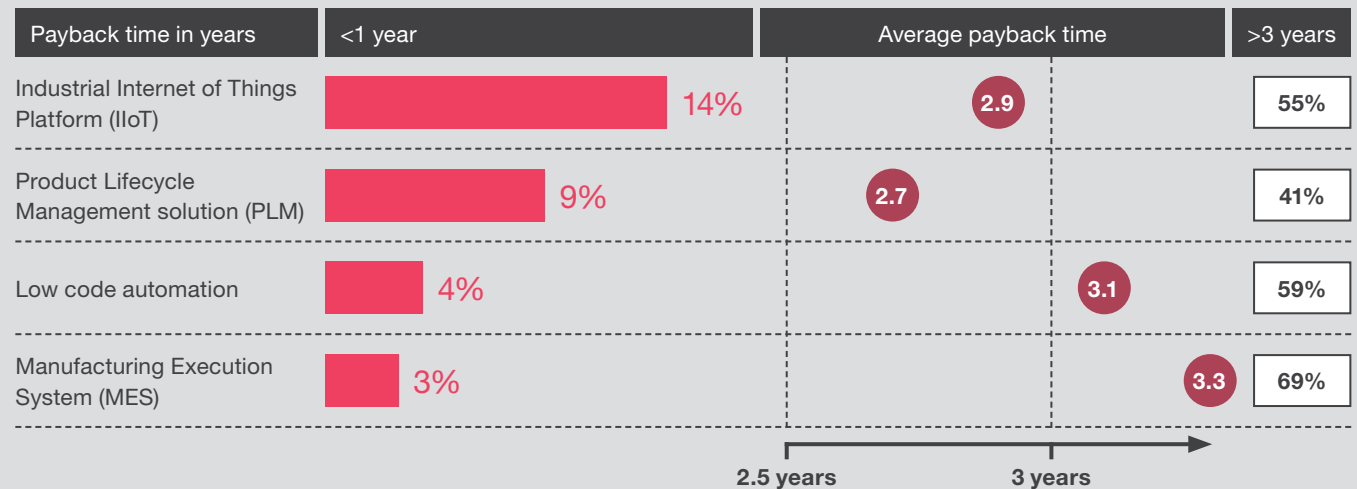
By contrast, companies say that MES has the longest average payback period at 3.3 years; only 3% of companies achieve or expect payback on MES investment within one year, and 69% expect payback after more than three years.

It may seem counter-intuitive that MES, the longest-established digital solution for manufacturing, is also the one that takes longest to deliver payback on investment. Our client experiences suggest that may be because many MES solutions are implemented without first harmonizing and standardizing processes, increasing the cost and timescale of implementation. It is also the case that not every plant needs an MES: a fully implemented ERP that can be paired with IIoT solutions can be a faster and more cost-effective digital backbone approach. Companies participating in the survey say that IIoT platforms have an average payback period of 2.9 years, and a significant minority of companies (14%) achieve or expect a payback period of less than one year.

Fig. 16   Payback timescale: digital backbone

Payback periods for selected IT solution implementations

Payback time in years	<1 year	Average payback time	>3 years
Industrial Internet of Things Platform (IIoT)	14%	2.9	55%
Product Lifecycle Management solution (PLM)	9%	2.7	41%
Low code automation	4%	3.1	59%
Manufacturing Execution System (MES)	3%	3.3	69%

2.5 years   3 years

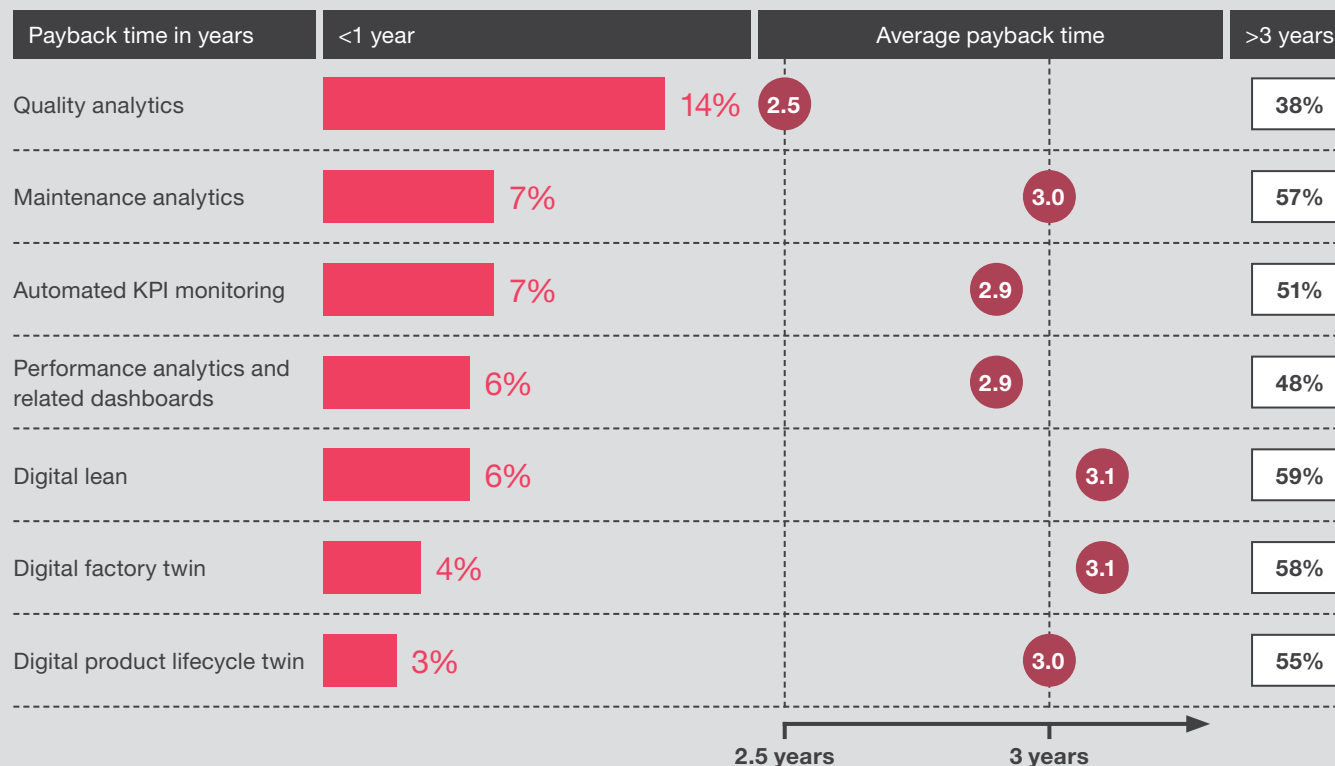Source: PwC Digital Factory Transformation Survey 2022

3.2 Use case payback

One use case stands out above all others in terms of payback: quality analytics. Quality analytics-related use cases have the shortest payback time with an average of 2.5 years, with 62% of companies in the survey achieving or expecting payback times of less than three years and a significant minority of companies (14%) achieving or expecting payback in less than one year. The case of Kraft Heinz (see below) shows how one large business is transforming its manufacturing operations by concentrating on leveraging the latest sensors and analytics technologies to facilitate continuous quality assurance, enabling immediate and fully automated interventions, and eliminating customer quality complaints.

The majority of use cases deliver payback on investment in three years on average. That said, at least 40% (62% for quality analytics and 41% for digital lean) of companies achieve an average payback time of less than three years across the use cases. The variation in payback timescales and the possibility of payback within one year or less shows that where use cases are well selected and well executed, digital use cases can have a positive impact on the bottom line within months rather than years.

Payback periods for selected use case implementations

Payback time in years	<1 year	Average payback time	>3 years
Quality analytics	14% — 2.5		38%
Maintenance analytics	7%	3.0	57%
Automated KPI monitoring	7%	2.9	51%
Performance analytics and related dashboards	6%	2.9	48%
Digital lean	6%	3.1	59%
Digital factory twin	4%	3.1	58%
Digital product lifecycle twin	3%	3.0	55%

2.5 years   3 years

Source: PwC Digital Factory Transformation Survey 2022

Automated KPI monitoring and performance analytics dashboards have an average payback of less than three years. The latter can be considered the mature stage of the former: through automated KPI monitoring and performance analytics, companies are now able to steer their production based on real-time KPIs to enable real-time responses.

Investment payback times for maintenance analytics use cases are somewhat longer, with an average timescale of three years. Experience suggests that this is because of the complexity of delivering the solution at scale and the complexity of the enabling systems that maintenance analytics demands. Existing assets may pose connectivity challenges, which increases the cost of implementation, and where machines are used to make a range of different products, bespoke algorithms may be needed to forecast performance and failure points. Yet faster payback is possible: 7% of companies in the survey reported achieved or expected payback of a year or less. By implementing maintenance analytics selectively, according to whether machinery demands basic condition monitoring, preventive maintenance or full predictive management, payback timescales comparable to the short timescale of the quality analytics use case can be achieved.

The expected and achieved payback period of the digital lean use case is surprisingly long, at an average of 3.1 years. Rapid savings can be achieved by digitizing factory status visualizations such as Gemba boards (and during the global pandemic many companies implemented an ad-hoc digitalization using online Gemba boards), but the extent of such savings will depend on whether key enabling services are already in place. When the analytics capacity is in place, digital lean can map and detect wasted materials and resources continuously, allowing faster and more accurate root cause detection of waste. Our client experience is that a fully supported digital lean implementation is a must-have use case for many Digital Champions.

The digital twin use cases (factory and product lifecycle twins) are also at the longer end of the payback timescale (at 3 to 3.1 years), reflecting the complexity of the use cases and challenges in implementation. Typically, digital twins build on other use cases, and demand a holistic data strategy since they require data from multiple sources such as the ERP, PLM, MES, IIoT, and standalone assets. The challenge lies in how to bring all of this data together and to life, given that data sources will have different maturity levels, and implementation calls for a very clear roadmap to the final target stage. Client experience tells us that the most promising digital twin implementations are built on IIoT platforms.
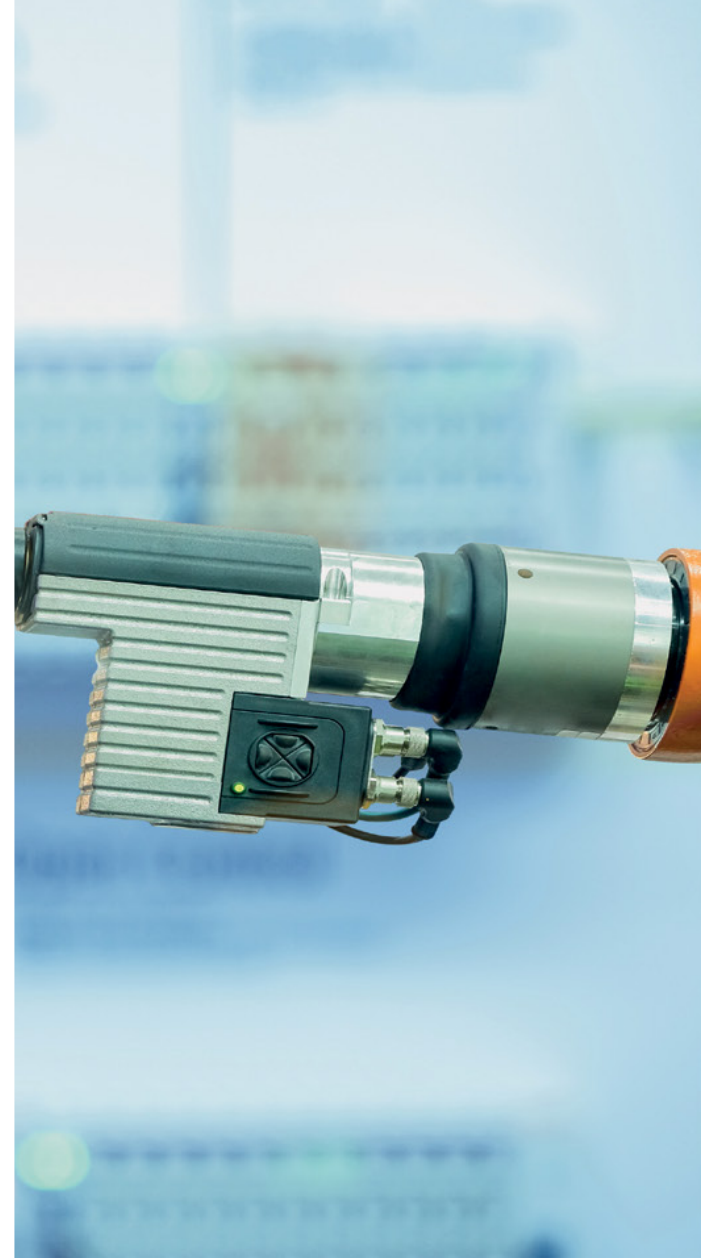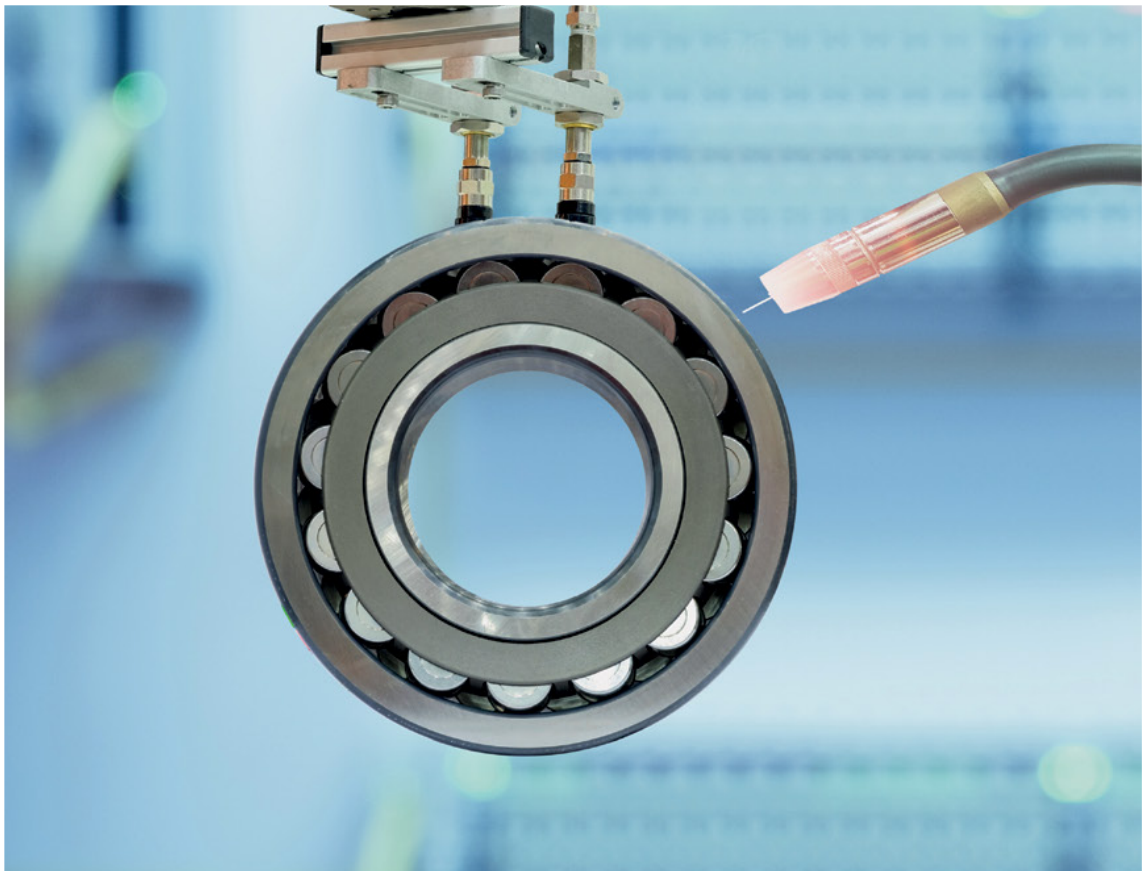
Kraft Heinz

Kraft Heinz aiming for fully digital production. Data governance and organisation are the key challenges for the global food giant.

Kraft Heinz is one of the largest food companies in the world, with operations in more than 40 countries and sales of over $26 billion. The company is in the midst of a transformation programme that includes transitioning to fully sustainable products and processes by 2025, and rolling out an agile digital ecosystem throughout its value chain. As part of this transformation, Kraft Heinz is also digitalising all of its production processes around the world.

For Kraft Heinz, the high road to total digitalisation begins at the factory level, and the company has three priorities when it comes to quality analytics: zero defects ("right first time"), end-to-end traceability, and eliminating customer complaints or returns.

The company says that the root cause of most product quality issues is human error rather than machine failure, so eliminating the human factor is the obvious path towards zero defects.

Kraft's digitalisation programme is designed to move production line processes beyond simple monitoring. Instead, the aim is to reach a point where data from sensors, cameras and X-rays can predict errors and defects before they start generating faulty products.

For example, Kraft Heinz began installing X-ray technology on its production lines around seven years ago, and today virtually every Kraft Heinz factory in the world has X-ray capabilities. This replaced the old manual system of carrying out spot checks by opening selected containers to check for defects.

Kraft Heinz has now also augmented this technology with a layer of automation and artificial intelligence (AI), using a machine vision system (MVS) that can analyse data from production line cameras. The MVS supervises production lines for products such as sauce sachets, which may appear simple but actually have multiple potential points of failure. Adding to the challenge is the fact that if just one sachet leaks or otherwise fails, the entire case of sachets has to be rejected.

"It is very difficult to maintain the integrity of the seal on those little sachets of sauce, but that is what we have to do," says Dr Lee Reece of Kraft Heinz. "There are actually about 50 different ways that particular manufacturing process can go wrong, so what we have done is teach the MVS to detect what could be a leak or a failure even if it doesn't look like a leak to the human eye."

"There was a time when the only way this could be done was to have a human operator standing over the line and every now and then taking a sachet and giving it a good twist to see if it would leak. But today, the MVS feeds the image data into our AI system, which can not only detect failure, but also failure about to happen. We have got to the point where production machinery can effectively check itself."

However, monitoring production quality and predicting failures are only the first steps on the road to a digital organisation. "When we first started looking at quality analytics, we knew we had specific problems to solve, such as the cost of putting large batches of product into 'quarantine' on the basis of a single production line error," says Dr Reece. "At that stage, we were thinking of something as simple as 'right ingredient, right place, right time'."

Another human process Kraft Heinz is replacing in quality analytics is the use of tastings for quality assurance. The company's quality experts are trained to taste any variations in the recipe, but working this way has its limits: tasting is not carried out continuously, and humans cannot detect small incremental changes in salt content that build up over time. Machines, on the other hand, can detect these tiny variations. By using the latest sensors and advanced analytics, Kraft Heinz has made significant progress in continuously monitoring the quality of its products and avoiding changes in taste and texture.

"We started to realise that there was scope for much more digital control. This was something that could be applied to pretty much every step in the manufacturing process. So it has grown from a single issue to a much bigger operations-wide opportunity, and we have taken our initial idea focussed on one specific area and extended it end to end to create digital manufacturing from inputs to distribution," says Dr Reece.

However, the company cautions that technology, automation and AI are only one element of creating a digital factory. Data governance, analytics capabilities and organisational response can be even bigger challenges.

"You can learn how to get data from your production lines," says Dr Reece. "The question then is what are you going to do with that data? How are you going to use it for intelligent decision-making? How are you going to integrate it into different systems? The earlier you can answer these questions, the more effective the digital transformation will be."
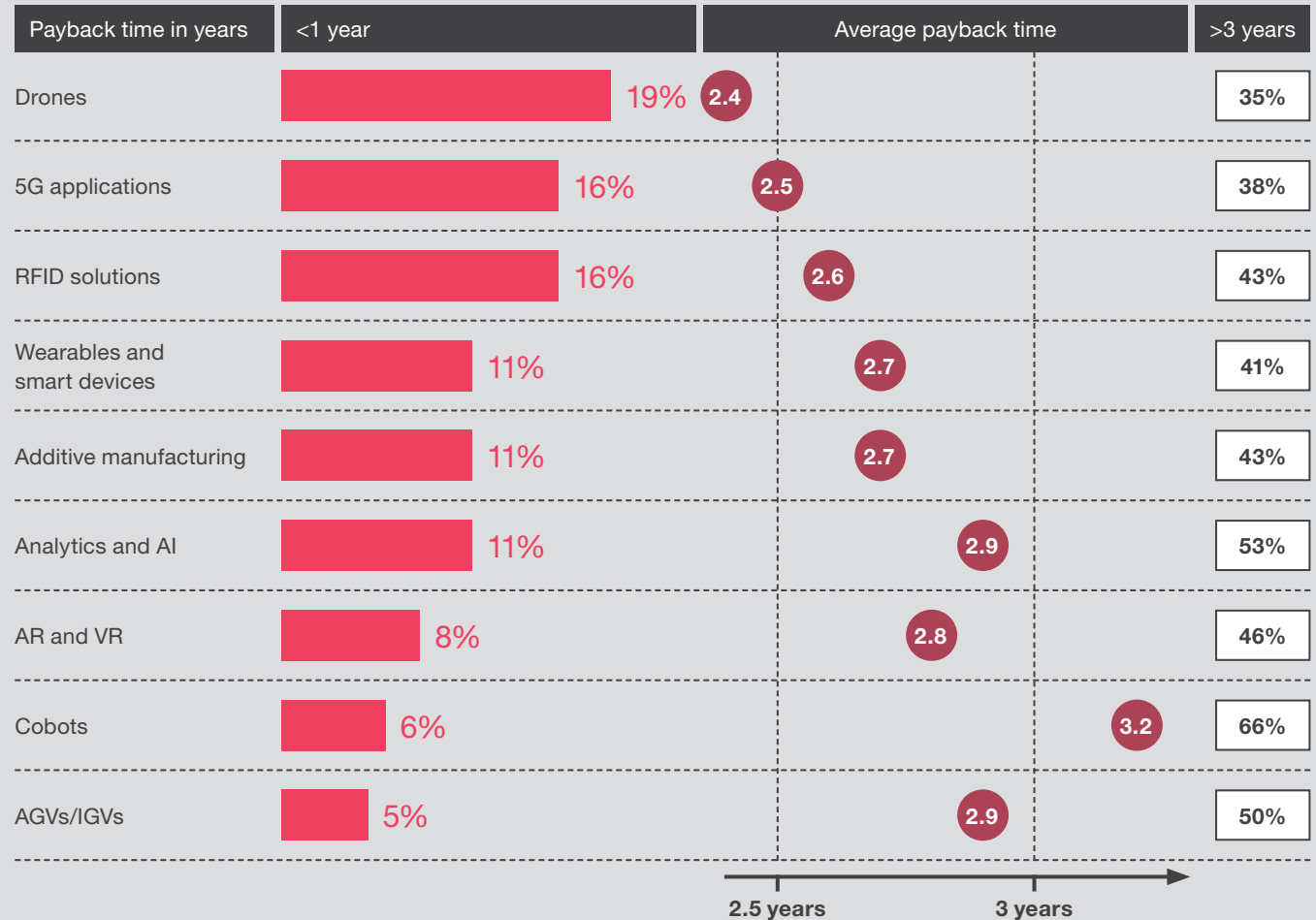
3.3 Technologies payback

Drones, 5G applications and radio frequency identification (RFID) solutions have on average the shortest payback period with an average of 2.4–2.6 years. Almost a fifth (19%) of companies saw investment payback on drones in less than one year, and a significant minority (16%) of companies achieved or expected investment payback on 5G and RFID in less than one year. Such rapid returns are particularly important within transformation programs due to the range of applications of each technology.

For example, drones are capable of inventory monitoring and maintenance rounds in dangerous or difficult-to-access areas. 5G applications can solve connectivity challenges for many assets, such as automated guided vehicles (AGVs), and complement existing networks, such as Wi-Fi. RFID solutions create a contactless information exchange that can be used to tag and track individually any component, material or product through production, shipping and receiving. This makes product individualization easier, reduces manual work, increases traceability and generates data feeding multiple use cases.

Fig. 18   Payback timescale: technology implementations

Payback periods for selected technology deployments

| Payback time in years	<1 year	Average payback time	>3 years
Drones	19% 2.4		35%
5G applications	16% 2.5		38%
RFID solutions	16% 2.6		43%
Wearables and smart devices	11% 2.7		41%
Additive manufacturing	11% 2.7		43%
Analytics and AI	11% 2.9		53%
AR and VR	8% 2.8		46%
Cobots	6% 3.2		66%
AGVs/IGVs	5% 2.9		50%

2.5 years   3 years

Source: PwC Digital Factory Transformation Survey 2022

Wearables, smart devices and additive manufacturing have an average payback period of 2.7 years, although 11% of companies achieved or expected payback within one year. Smart devices and wearables, such as smart watches, can be used to send maintenance staff alerts for unexpected machine failures and completion of tasks can be logged through the device, removing the need to return to a terminal and enter data.

Additive manufacturing enables fast and cheap production of individual parts and parts with complex geometries. This technology also opens up new product development opportunities as companies can develop lighter and stronger parts than with conventional manufacturing technologies, pushing the boundaries of prototyping and enabling flexible short-run product individualization (for further details please refer to our additive manufacturing survey "The future of spare parts is 3D: A look at the challenges and opportunities of 3D printing").

Manufacturers report longer payback timescales for analytics and AI, with more than half of companies (53%) seeing payback in more than three years, and slightly longer timescales still for augmented/virtual reality (AR/VR) technologies, cobots and automated/intelligent guided vehicles (AGVs/IGVs) where payback averages 2.8 to 3.2 years. Fewer than 10% of companies are achieving or expecting rapid payback within one year.

Client experience tells us that AI requires extensive internal competence building as companies learn how to leverage their data. The challenge for AGV/IGV implementation is different: companies have struggled to define internal standards for AGVs and to integrate them within the orchestrating system, while the necessary shop floor adaptations require a high degree of flexibility. Comparable challenges are raised by cobots, and the expectation of easy integration of cobots into existing production processes has not always been fulfilled.
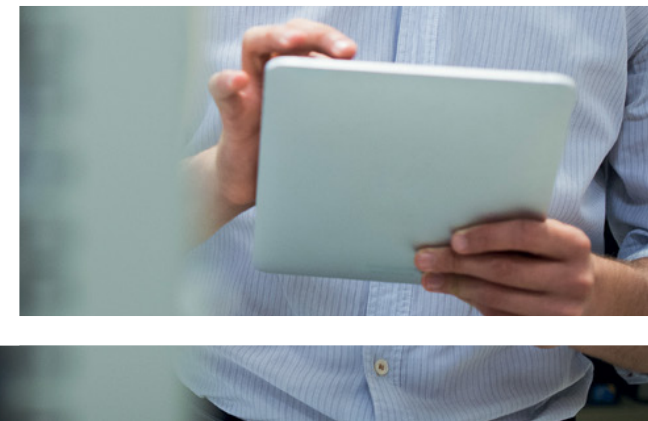
E Organizational set-up

Transformations rarely happen effectively without the right organizational set-up, and an underlying operating model adapted to the needs of digital transformation and the companies' boundary conditions. The most effective transformations take place when companies embrace an agile delivery model. The operational set-up, however, needs to evolve over the course of the transformation from a more "centralized approach" towards a less centrally managed, hence embedded, approach.
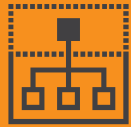
1. An agile target operating model to run the digital transformation is essential

There are sharp differences in approach between mature Digital Champions who have implemented a wide range of technology solutions and digital novices, who are at the beginning of the road that leads to the digital factory. Companies that have a record of achievement in digital transformation tend to stress the fitness of their organization for digital change, and the need for a clear grasp of the final operating model they are pursuing. Digital novices are more concerned about the details of their transition. Overall, Digital Champions are more concerned about where they are going and less concerned about how they get there.

Digital Champions are far more likely than others to cite the 'right organizational set-up' and 'target operating model' as one of their top two success factors – 22% of Digital Champions said this, compared with only 9% of novices. Digital Champions are also more likely to select a standardized overall transformation approach and standardized machine connectivity; novices by contrast are more likely to stress issues such as funding and roadmap which may reflect the fact that novices are at an early stage in digital transformation where these issues have greater significance.

Organizational set-up and the underlying operating model is the foundation for the transformation. As a result, it is key to f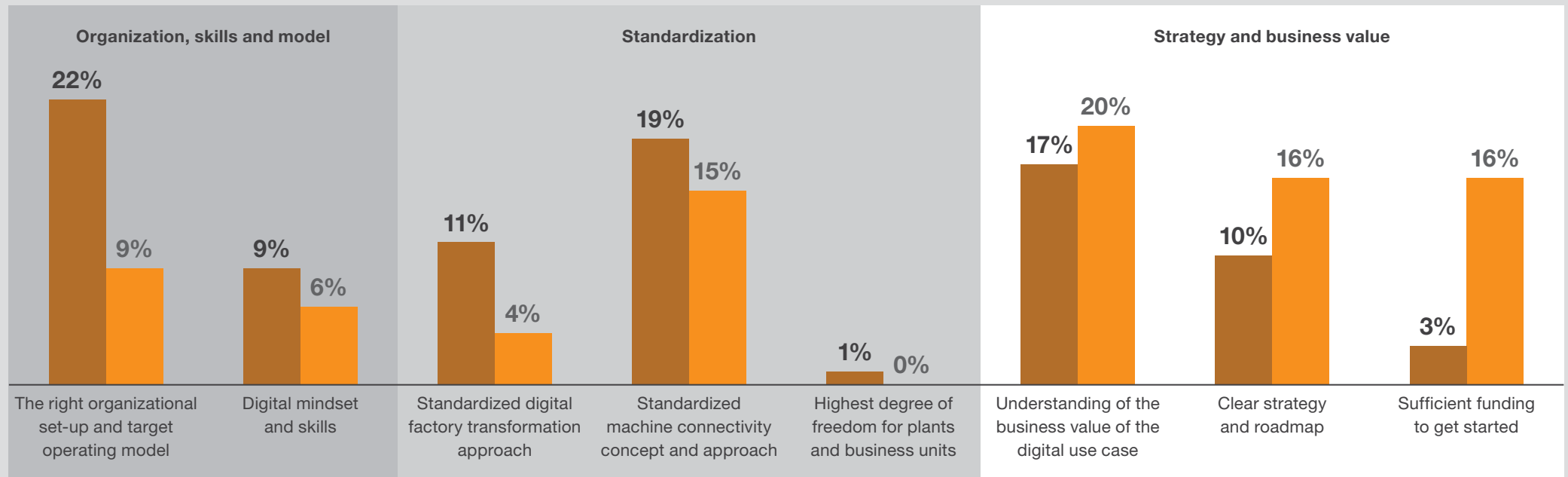orm joint teams between business and IT, and it is important to free up the right people to drive the transformation and to fill in capabilities that are not available through external hires. From the beginning of the transformation, resource requirements need to be planned carefully, especially in companies where the hiring process is lengthy or countries where certain resources are scarce. Client experience shows that lack of appropriate human resources is a critical obstacle to effective digital transformation.

The underlying operating model must also be addressed early. Companies need to decide whether they want to drive their transformation with a traditional 'waterfall' approach or an agile model. We believe that an agile operating model is the right approach for many companies and many transformation strategies. However, this requires training and a dedicated transformation team. The ZF success story above demonstrates how companies that are used to traditional waterfall planning can efficiently and effectively switch to a user-centric agile operating model.

The conclusion must be that experience teaches the importance of standardization and working with agile frameworks like SCRUM and SAFe, plus an interdisciplinary team set-up of business users, developers, and IT operations experts (BizDevOps) to enable continuous value generation.

Fig. 19   Key success factors for a digital factory transformation

Organization, skills and model

- The right organizational set-up and target operating model: Digital Champions 22%, Novices 9%
- Digital mindset and skills: Digital Champions 9%, Novices 6%

Standardization

- Standardized digital factory transformation approach: Digital Champions 11%, Novices 4%
- Standardized machine connectivity concept and approach: Digital Champions 19%, Novices 15%
- Highest degree of freedom for plants and business units: Digital Champions 1%, Novices 0%

Strategy and business value

- Understanding of the business value of the digital use case: Digital Champions 17%, Novices 20%
- Clear strategy and roadmap: Digital Champions 10%, Novices 16%
- Sufficient funding to get started: Digital Champions 3%, Novices 16%

■ Digital Champions   ■ Novices

Source: PwC Digital Factory Transformation Survey 2022

"
While most business leaders are focused on dealing with immediate challenges, now is the time to embrace digitization and ensure long-term business continuity."

Chief Financial Officer,
global pharmaceutical group

2. Digital Champions evolve from a centralized to an embedded organizational set-up

As we have already seen, Digital Champions consider that developing the right organizational set-up and a clear target operating model are the most important success factors when it comes to digital factory transformation. However, our survey also shows that the organizational structure needs to evolve over the course of the transformation to get the most out of the organization and facilitate rapid scaling.
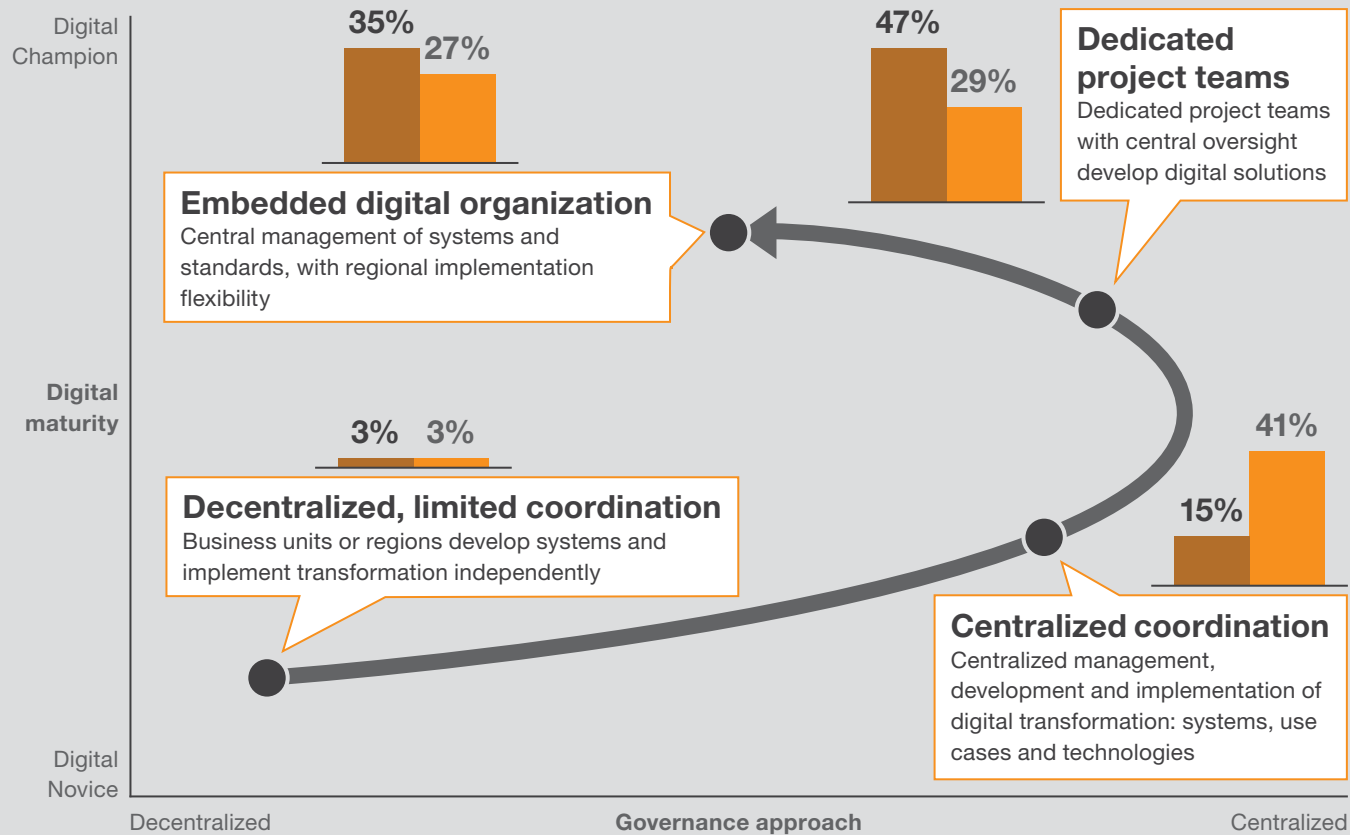
The PwC Digital Factory Transformation Survey 2022 shows that most companies start their transformation journey with a centralized approach to digitalization. This means that they centrally manage, develop and implement their digital systems, use cases and technologies: almost 40% of novices follow this approach. However, many companies quickly learn that rigid centralization is not the optimal structure for an effective transformation throughout diverse operations, and it is notable that only 15% of Digital Champions carry on with a centralized governance model.

More than 80% of Digital Champions have moved away from centralized governance towards a more balanced model that stresses centralized determination of principles, standards and digital backbone development, with implementation of use cases and technologies managed at local level, while leveraging central resources for scale and speed. A mere 3% of the companies drive their digital transformation on a decentralized model with limited coordination.

An embedded organization has the clear advantage that it enables functions outside of the core transformation team also to drive the digital transformation using guiding principles laid out by the central management. In this way companies can leverage the full innovation power of their workforce whilst maintaining a necessary level of standardization and harmonization. This facilitates scale at greater speed while avoiding unnecessary costs through standardization and harmonization.

Fig. 20   The digital maturity path

Digital
Champion

35% 27%

47% 29%

Dedicated project teams
Dedicated project teams with central oversight develop digital solutions

Embedded digital organization
Central management of systems and standards, with regional implementation flexibility

Digital
maturity

3% 3%

41%

15%

Decentralized, limited coordination
Business units or regions develop systems and implement transformation independently

Centralized coordination
Centralized management, development and implementation of digital transformation: systems, use cases and technologies

Digital
Novice

Decentralized   **Governance approach**   Centralized

Source: PwC Digital Factory Transformation Survey 2022

"

The power that technology provides enables digital transformation but in my opinion transformation is much more about culture, people and consumer change."

IT Leader, high-tech and electronics group

The lesson of the PwC Digital Factory Transformation Survey 2022 is that successful digital transformation demands elements of centralized standard-setting to establish best practices and guidelines, accompanied by decentralized teamwork for local implementation. Over-centralization fails to leverage all of the potential knowledge within the organization; lack of

centralization undermines the opportunities to transform at scale and at speed. The formula for success is that the digital backbone, standards and principles should be developed, managed and orchestrated centrally, while individual solutions and factory-related implementations should be embedded in the business.

Resource and governance allocation guide

Central governance

- ▶ Digital strategy, vision and overarching value proposition
- ▶ Orchestration, management and development of the digital backbone and related systems
- ▶ Platform and enabling services
- ▶ Template management of core system functionalities
- ▶ Process harmonization and standardization
- ▶ Management of connectivity standards
- ▶ Definition of guiding principles and standards
- ▶ Program management and control
- ▶ Budget management
- ▶ Big data and analytics centre of excellence
- ▶ Emerging technology scouting
- ▶ Digital change and training
- ▶ Start-up incubation, digital lab and ring-fencing of ideas
- ▶ Strategic partnering and ecosystem orchestration

Embedded in the business

- ▶ Digital leadership/pride builders and communities
- ▶ Use case envisioning and development
- ▶ Technology implementation
- ▶ Low code automation solutions development
- ▶ Provision of subject matter experts
- ▶ Development of plant-specific add-ons and templates in alignment with central governance
- ▶ Asset connectivity
- ▶ Industry-specific digital platform and go-to-market approach

F   A blueprint for successful factory transformation

Digital factory transformations are very specific for each company, based on individual operational targets or the organizational DNA. There is no single model for success – but there is an established transformation blueprint that includes key questions every company should answer before committing to a digital transformation path. Companies that have mastered successful factory transformation have not only focused on best-in-class technology solutions – they have also spent significant effort in setting up an effective transformation organization and governance. In addition, they put communication with their employees and adequate training first – and return to these people topics as they proceed through the various implementation phases.

?

These are some of the key questions that each company should answer:

- What is the best way to evolve the organizational set-up to deliver factory transformation based on the company's digital maturity?

- How does the company identify the resource requirements for functional and IT positions, including how many people and when they are needed at each stage of the transformation path?

- Is the optimal operational delivery model agile or waterfall, and how should the company prioritize tasks in the delivery model?

- What is the most effective way to drive change in the company and keep communicating with key employees throughout the transformation?

- How should the company develop a training and external hiring concept to deliver transformation?

- How can the company best support its workforce throughout the transformation?

The answers to these questions will help determine the design and implementation of a digital transformation.

▶ **Digital strategy, vision and roadmap**
Companies should be clear about their strategic targets and their digital vision. Targets and vision become the essential guardrails when it comes to the selection of use cases, applications and technologies. Companies should consider scalability right from the start, thinking through their dependence on underlying enabling services, resources and data requirements for likely use cases and technologies. Once use cases, technologies and applications are defined, a detailed business case should be developed to validate and potentially modify the transformation focus areas. In addition, the required resources and employee qualifications need to be validated.

▶ **IT architecture design**
The architecture archetype, or digital backbone, is the key to achieving targets. The underlying IT architecture is both a solution and a risk area where companies can potentially lose the capability to implement at speed and scale. For some capabilities, such as established MES solutions, the IT architecture decisions are relatively straightforward; for others such as customized traceability solutions, performance analytics or digital twin applications, decision-making is more challenging because such applications are case-specific. Companies should also address shop floor connectivity: the earlier that questions about connectivity standards for line of business data and assets are addressed, the easier implementation becomes.

▶ **Use case and technology requirements detailing**
Use cases and technologies should be selected based on critical business needs. Companies should pre-select use cases and technologies that can be standardized and scaled up across multiple plants. They also need to be rigorous about what is

a must-have and what is a nice-to-have application: the nice-to-have category frequently proves to be a driver of cost and not of resilience, flexibility, transparency or efficiency. Digital requirements are not the only criterion for selecting use cases and technologies: supporting processes, people skills and end-user needs and capabilities are also important. As always, processes, systems and people need to be in synch for a successful transformation.

▶ **Vendor strategy**
Companies should consider first whether to make or buy a digital solution. For third party solutions the biggest cost driver is the decision as to whether an existing standard solution is sufficient, or whether a high level of customization is required to make it fit for purpose. Solution provider decisions tend to be simple calculations of requirement fulfilment versus total cost of ownership. System integration poses greater challenges: how will system integration match current and future in-house capabilities and resources, and how will system integrator responsibilities and accountabilities be managed? Companies may choose internal management for greater control or outsourcing to a general systems contractor for clearer accountability.

▶ **Agile platform, system, use case and process development**
During the development phase, the key question is whether an agile delivery model or the traditional waterfall model is best. The larger the in-house development or customization component, the more beneficial an agile delivery model becomes. This phase starts with sprint-based system, template and process blueprinting and continues with coding and customization, allowing for constant feedback and agile requirement adjustments. Client experience shows the value of continually testing solutions with internal end users to ensure user acceptance and the full implementation of benefits of a solution.

Schaeffler

How Schaeffler is achieving end-to-end digitalisation. Connectivity is the key to Schaeffler's digital factory transformation.

Schaeffler is a leading global automotive and industrial supplier headquartered in Bavaria, Germany, and is one of the world's largest family-owned companies. It deploys a range of innovative technologies and digital Industry 4.0 processes to deliver high-precision components and systems for powertrain and chassis applications, as well as roller bearing and plain bearing solutions for a large number of industrial applications, with many products focused on electric propulsion. Schaeffler's mission is to be the partner of choice for making mobility more efficient, more intelligent and more sustainable.

Schaeffler has a clear vision for 2030: a modular, flexible and digital end-to-end (E2E) production model throughout its manufacturing operations.

The foundation of realising this vision is connectivity. Schaeffler began by focusing on connecting machines and equipment on a global scale. The ambition is to have around 2,500 extra machines connected by the end of this year and another 3,500 by the end of 2023 while ensuring the highest operational technology (OT) security standards.

The company's governing principle is to adhere to a single standard for connectivity, data collection and OT security, with a single connectivity layer to all systems, including the company's manufacturing execution system (MES) and industrial internet of things (IIoT) platform. The standard must be capable of exchanging messages that perform common tasks in distributed systems, such as asking and answering questions, making and processing statements, and stream processing.

Schaeffler's aim was to create a single source of truth for all parts of the manufacturing process, with the ability to generate data that can be analysed by smart algorithms and help with decision-making.

In the real world, however, an ideal data and connectivity model cannot be rolled out at a stroke across a diverse manufacturing network. New skills and a supporting organisational structure had to be developed to enable people to implement the connectivity project. To achieve this, Schaeffler has been empowering its employees by means such as connectivity training and OT security training.

Connecting machines and establishing the right skills and organisational structure is a clear strategic commitment by Schaeffler. Upfront investment will facilitate many use cases and will also make the rollout of the company's new MES significantly easier. As a result, there will be a return on the investment – just not in the short term.

On top of this connectivity initiative, Schaeffler has identified the need to make cloud-based production IT infrastructure scalable for its global production network, which is made up of facilities with different levels of production process maturity operating in different product segments.

To achieve an effective rollout across this diverse network, Schaeffler has adopted a combined bottom-up/top-down approach to implement the company vision. The top-down component sees Schaeffler distributing technologies across the network of facilities to enable individual use cases. The bottom-up dimension sees individual plants creating specific use cases that are assessed for return on investment (ROI) in that factory. Where ROI is positive and the use cases are scalable, they are added to the network-wide implementation portfolio.

For example, one use case which has already been implemented is Schaeffler's throughput time analysis tool, which makes the production supply chain fully transparent and is used by production planners, supply chain managers and the management board. This is a cloud-based tool capable of analysing the real E2E throughput time of more than five million inputs globally, connecting more than 400 million data points in the MES and enterprise resource planning (ERP) system every month as well as shop floor control systems, supporting shorter throughput time and helping to reduce inventory.

A second example is digital shop floor management (SFM), which is active at eight manufacturing sites. This eliminates manual data processes and the administrative burden this involves by replacing paper-based shop floor management with automated collation of data from machines and employees in near real time. The data is distributed to on-screen visualisations known as SFM boards.

In addition to the sustainability benefits of not using paper, there are also cost and quality benefits. The digital SFM tool enhances the standardised SFM process, allows problems to be solved cost-effectively as they emerge rather than expensively after the fact, and helps to create best practice models.

According to Schaeffler, a transformation like this could not have been implemented without structured organisational support capable of planning the rollout and allocating resources in the company's 70 manufacturing locations worldwide. The company has three layers of organisational control over the transformation project designed around a what-how-who structure: Business Demand Coordination and Digital Competencies work with plant managers to decide what resources are needed; Operations IT Governance determines how use cases can be implemented; and IT Solutions and Services is responsible for delegating responsibility for development and implementation.

Schaeffler's intention is that all future factories will be integrated and intelligent parts of its global supply chain network, dynamically connecting and interacting with each other. The aim is to develop supplier-customer relationships that are more resilient and more reactive to changing market needs, with all products and processes becoming sustainable, and all factories flexible enough to vary product specifications as fast as the market demands.
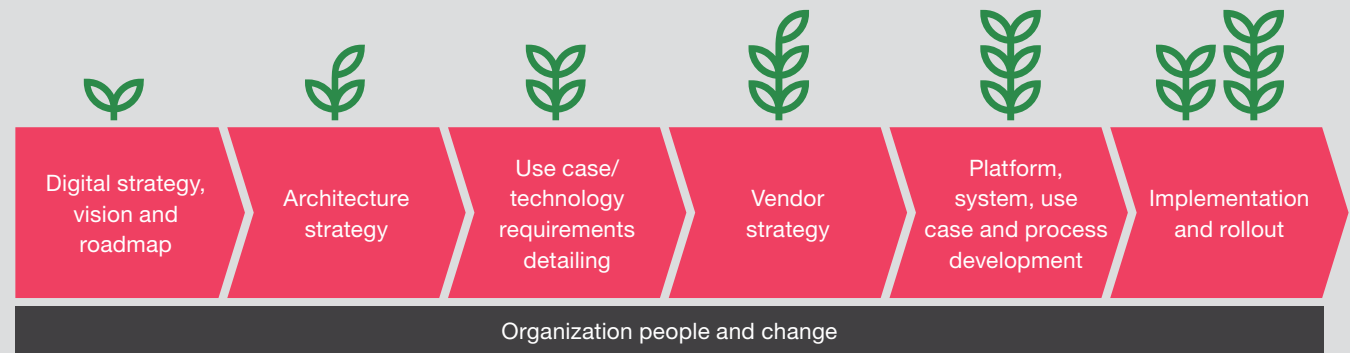
> "Even with the best technology and processes, the pace is difficult to maintain if leaders fail to convey goals clearly and frequently, or if activities fail to involve affected teams adequately."
>
> Chief Operating Officer,
> high-tech and electronics group

Fig. 21 The shorter road to factory transformation

Digital strategy, vision and roadmap → Architecture strategy → Use case/ technology requirements detailing → Vendor strategy → Platform, system, use case and process development → Implementation and rollout

Organization people and change

Source: PwC Digital Factory Transformation Survey 2022

▶ **Implementation and rollout**
The level of standardization and harmonization of digital solutions determines the number of use cases and implementation complexity. Digital rollouts can be executed system by system, use case by use case or in a "big bang" simultaneous implementation – but the speed of simultaneous rollout carries its own risks, and companies should make a prior risk-benefit assessment. The successful scaling of solutions across factories is also critical: based on a pilot plant implementation, key plants across regions or business units should be addressed in a second wave before a company-wide roll out. In addition, each factory needs to decide whether a full implementation of all use cases is economically viable, or whether a partial or base version of factory intelligence is sufficient for some sites. Individual use case solutions should be kept to a minimum, but at the same time a fully-fledged "gold" implementation versus a partial "silver" implementation might prove the most economical decision.

▶ **Organization, people and change**
Driving digital transformation jointly with all employees and ensuring people acceptance is the most important task. Neglecting active change management is the underlying cause of slow or failed digital transformation programs. Digital Champions spend significant resources on developing digital training programmes, providing sufficient time for employees to attend the training and hiring selected outside talent if certain capabilities cannot be developed in-house. In addition, an effective transformation organization needs to be established to ensure adequate guidance and governance. Most Digital Champions establish a centralized organization to provide standards, common methodologies and technology selections, while allow empowered teams in the regions or business units to take ownership of effective solution implementation in the factories.

Methodology

The PwC Digital Factory Transformation Survey 2022 was conducted in the second half of 2021 and gathered responses from 700 global corporations from at least 23 different countries to find out about the status of their smart factory transformation, their priorities in technologies and use cases, as well as their general transformation approach. Survey respondents were drawn equally from companies in six sectors: retail and consumer goods, high-tech and electronics, chemicals and process industries, pharmaceuticals and medical technology, automotive and transportation, and industrial manufacturing. Respondents were C-suite executives or operations leaders, with 70% of companies represented having revenues in excess of €3 billion.

The survey classifies companies into four categories depending on the maturity of their digital transformation and the extent of their technology implementations: the highest scoring 10% of survey participants are considered Digital Champions that have fully or largely completed their digital transformations, followed by Innovators (30%) that have achieved substantial progress in their transformation programs, Followers (40%) that have developed transformation roadmaps and are at an early implementation stage, and Novices (19%) that remain at the stage of conceptualization and planning.
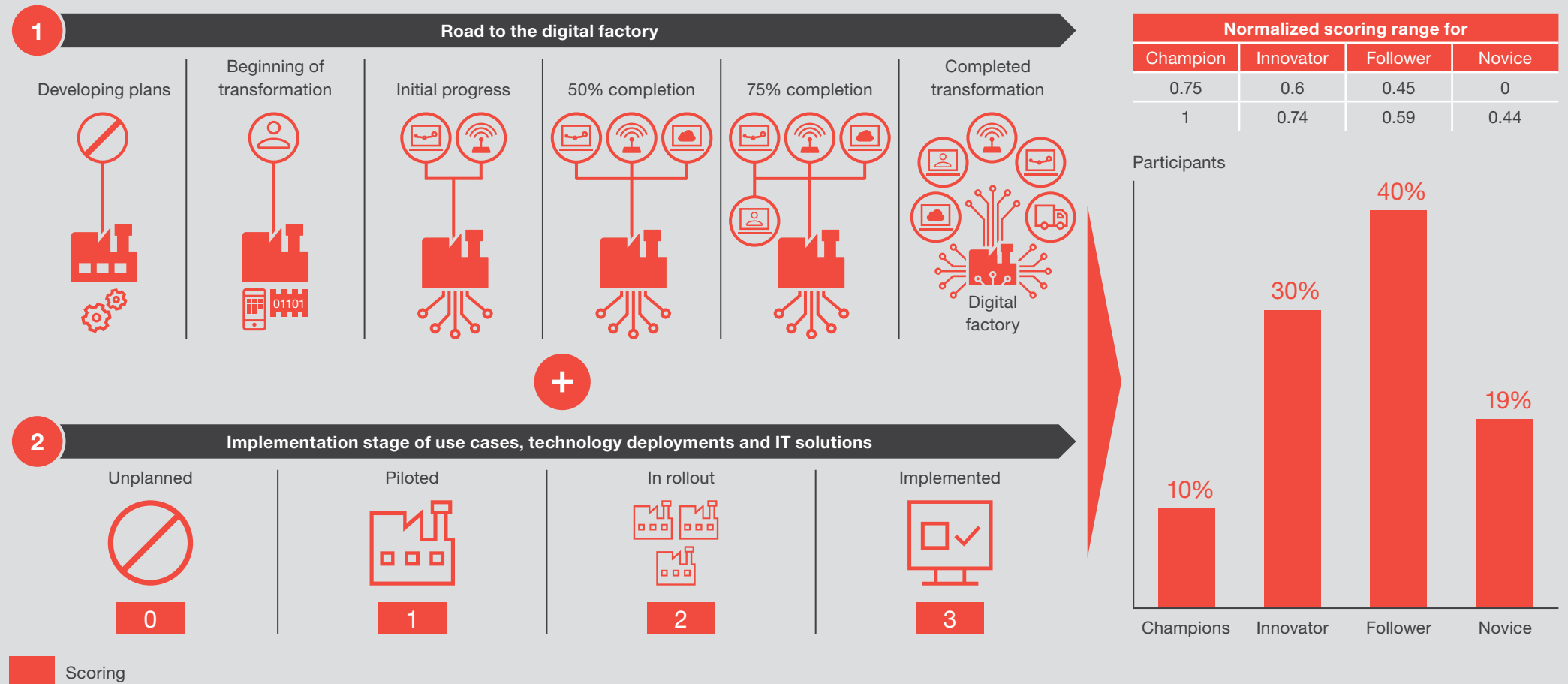

Fig. 22   We conducted 700 interviews on a global scale in various industries to provide a current status update on digital factory transformation and to highlight best practices

Company size by global gross revenue

10%

20%

35%

35%

■ >€5bn   ■ €3–5bn   ■ €1–3bn   ■ <€1bn
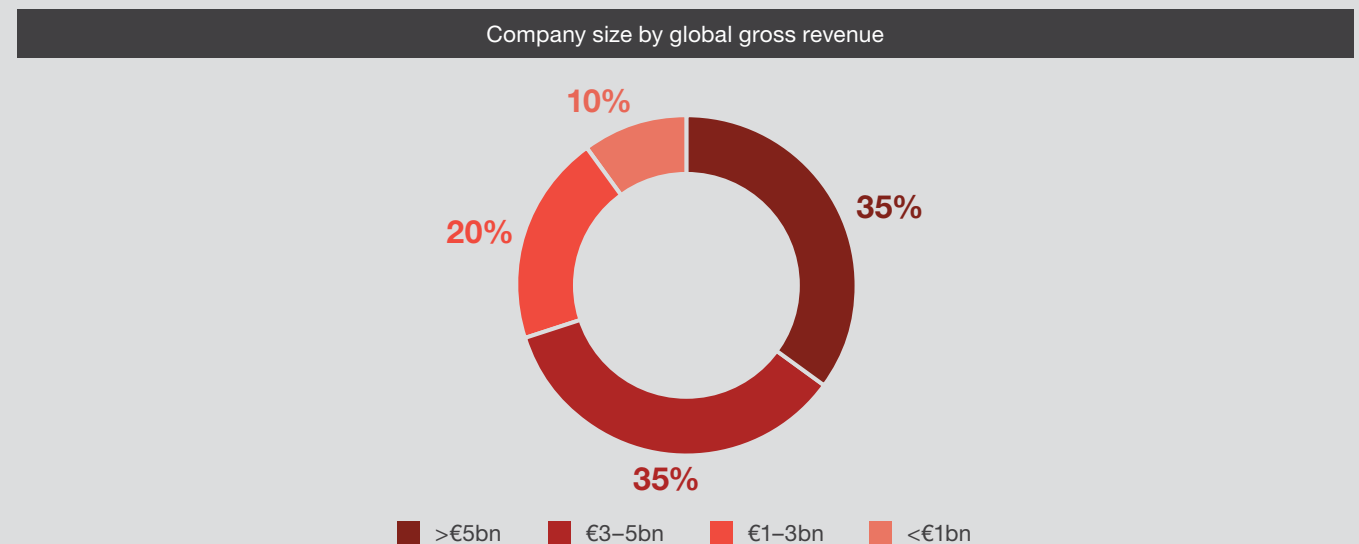
Source: PwC Digital Factory Transformation Survey 2022

Fig. 23   Digital Champions classification

① Road to the digital factory

| Developing plans | Beginning of transformation | Initial progress | 50% completion | 75% completion | Completed transformation |

Digital factory

② Implementation stage of use cases, technology deployments and IT solutions

| Unplanned | Piloted | In rollout | Implemented |
| 0 | 1 | 2 | 3 |

■ Scoring

Normalized scoring range for			
Champion	Innovator	Follower	Novice
0.75	0.6	0.45	0
1	0.74	0.59	0.44

Participants

Champions	Innovator	Follower	Novice
10%	30%	40%	19%

Source: PwC Digital Factory Transformation Survey 2022

Glossary

MES/MOM – Manufacturing Execution System/ Manufacturing Operations Management	MES/MOM is the operational control element of the factory. It integrates the top floor with the shop floor, and schedules, executes and steers operations across production, inventory, quality and maintenance.
Cobots – collaborative robots	Cobots are robots that allow direct collaboration with humans and are designed to share a workspace with them. Unlike traditional industrial robots, they are not isolated from human contact. They are easy to train and therefore flexible to use.
E2E – end to end	End to end covers a whole process – from beginning to end to deliver complete outcomes.
ERP – Enterprise Resource Planning	ERP is the strategic/business control element of the factory. ERP manages resources such as capital, personnel, material and operating resources. It is the connection to other functions and provides communication channels and essential information such as demand, goods received, financials, procurement data and HR details.
IIoT – Industrial Internet of Things	IIoT facilitates advanced analytics like data mining, AI or machine learning and integrates multiple functions/solutions like MES, ERP or control systems across the value chain. It also provides a channel for integrating third-party information.
PLM – Product Lifecycle Management	PLM is a strategic approach to managing the end-to-end (E2E) product lifecycle within an integrated IT system landscape. It embraces the entire value chain of an industrial company. PLM integrates all necessary processes and information that accrue during the entire E2E lifecycle of any product an industrial company brings to market.
Low code automation	Low code automation enables automation of workflows with limited programming skills. It enables business units to become more flexible and to develop automated workflows using a combination of visual interfaces and coding sectors, without the involvement of IT departments.
SLA – Service level agreement	Service level agreements are commitments between a provider and a customer documenting what services the provider delivers and which standards must be met.

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