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The next horizon for industrial manufacturing: Adopting disruptive digital technologies in making and delivering

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The key to continued performance and productivity improvement for advanced industrial companies is the use of disruptive technology in the manufacturing value chain.

In the past few years, advanced industrial companies have made solid progress in improving productivity along the manufacturing value chain. In the US, for instance, the productivity of industrial workers has increased by 47 percent over the past 20 years. But the traditional levers that have driven these gains, such as lean operations, Six Sigma, and total quality management, are starting to run out of steam, and the incremental benefits they deliver are declining.

As a result, leading companies are now looking to disruptive technologies for their next horizon of performance improvement. Many are starting to experiment with technologies such as machine-

to-machine digital connectivity (the Industrial Internet of Things, or IIoT), artificial intelligence (AI), machine learning, advanced automation, robotics, and additive manufacturing. The impact of this shift is expected to be so transformative that it is commonly referred to as the fourth industrial revolution, or Industry 4.0.

This new wave of technology and innovation offers companies opportunities not only to drive a step-change in productivity and efficiency, but also to capture strategic business value by establishing competitive advantage in the way they operate their entire “make to deliver” value chain. The nature

and scale of the opportunities will vary from sector to sector and company to company, depending on factors such as value drivers, market dynamics, and operational maturity. However, we routinely see successful technology-enabled transformations dramatically shifting individual value drivers. For example, an aerospace manufacturer with a reputation for high quality but suffering from high labor costs and slow production implemented augmented-reality work instructions for complex assemblies to decrease error rates from 3 percent to nearly 0 percent while increasing productivity by

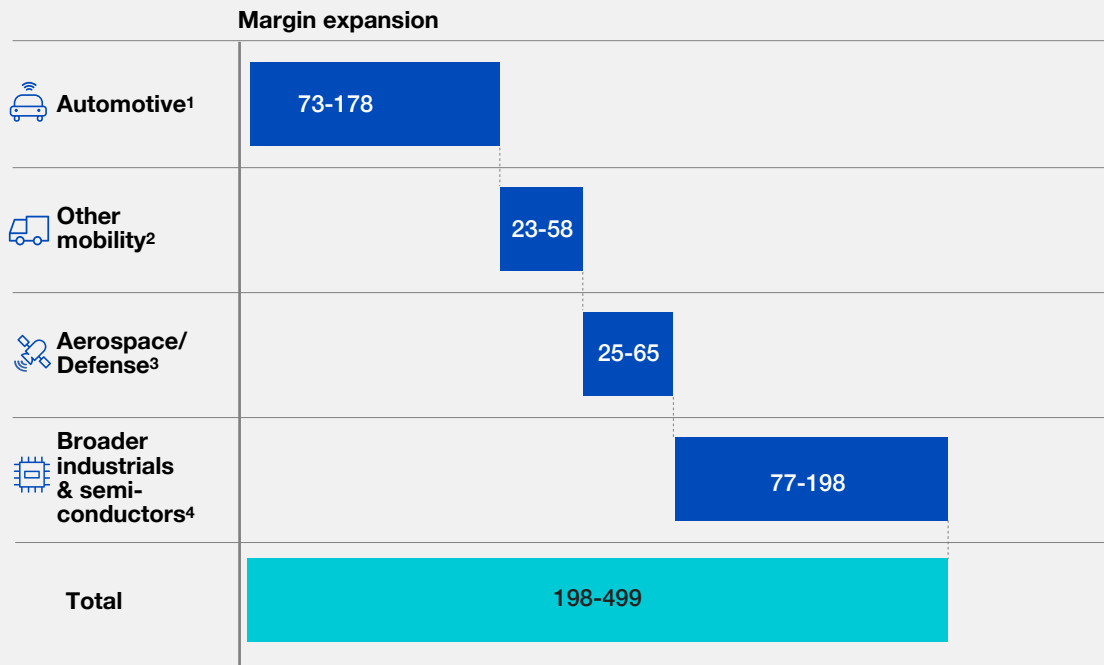
30 percent. Similarly, an auto manufacturer that needed to maximize its already highly automated process began analyzing available data for micro-losses in capacity to unlock an additional 3 percent of overall equipment effectiveness. Finally, an electronics manufacturer operating in a high-cost country virtually eliminated material handling labor using automated vehicles for material delivery and robots for palletizing.

For companies that aim well and execute effectively, the resulting cost reductions could be

EXHIBIT 1

The value from tech enablement in product manufacturing and delivery varies by industry segment

\$ billions



Cost reduction value will be exceeded by revenue growth through strategic value drivers, e.g.: speed to market, customization, responsiveness, and new services

¹ Whole value chain including tier-one suppliers, automotive OEMs, and dealers

² Commercial vehicles and off-highway equipment (e.g., for construction and agricultural use) including tier-one suppliers, equipment manufacturers, and dealers and distributors

³ Includes tier-one suppliers and equipment manufacturers

⁴ Includes industrials, food processing and handling, motion and controls, industrial automation, and electrical, power, and test equipment across the value chain: component suppliers, equipment manufacturers, distributors, VARs, engineering and services providers, and product companies

transformational. We estimate that productivity gains and cost savings alone could deliver near-term impact of 200 to 600 basis points of margin expansion across advanced industries, worth \$200 billion to \$500 billion (Exhibit 1). In the mid- to long-term, even more value could be unlocked through greenfield plants, network reconfiguration, and upgrades to core IT and operating-technology (OT) architecture.

Substantial though these cost reductions are, we expect them to be overshadowed by new revenue opportunities arising from increased speed to market, product customization, and new services. How much strategic business value they will

generate remains to be seen, but we can expect the lion's share of it to go to first movers.













Unlocking the value

To capture the value of digital in manufacturing and throughout the supply chain, leading industrial companies are developing use cases in three main areas: connectivity, intelligence, and automation (Exhibit 2).

Connectivity

After rapidly expanding through the Internet of Things, connectivity has reached global scale, extending to some 8.4 billion connected devices. The ability to link digital devices—shop-floor monitors,

EXHIBIT 2 Connectivity, intelligence, and flexible automation create value across multiple aspects of manufacturing and delivery

Sources of value	Connectivity Enabling the flow of relevant information to the right decision makers in real time	Intelligence Applying AA and AI to an array of data to generate new insights and enable better decision making	Flexible automation Using new robotic technologies to improve the productivity, quality, and safety of operational processes
Optimizing procurement	 Advanced spend intelligence and automated sourcing insights	 Analytics-enabled tools for optimizing product cost (e.g., part number consolidation, digital benchmarking)	 E-sourcing events: eRFx, e-catalogs, e-auctions
Enhancing forecasting and demand planning	 Real-time tracking of inventory location	 Simulation-based forecasting of market and micromarket demand and inventory management	 Automation of production planning processes
Digitizing manufacturing and assembling	 Real-time OEE visibility with click-through capability on drivers of downtime	 Predictive maintenance to reduce downtime	 Vision systems for autonomous quality control
Streamlining distribution and delivery	 Real-time visibility of delivery windows	 Use of AA and AI to optimize logistics network	 Automated warehouse picking and replenishment

remote computers, smartphones, tablets, and so on—to IT platforms and systems enables decision makers to access a flow of relevant information in real time. In production environments, only 15 percent of assets are connected as yet, but change is taking off. Advanced applications now being introduced in industrial manufacturing include digital performance management and the use of augmented-reality smart glasses to communicate instructions and standard operating procedures. In the supply chain, parts are being tracked digitally across supplier networks, and trucks are providing real-time data to enable just-in-time delivery, optimize work planning, and minimize inventory. The technology industry is working on more than 700 IoT platforms for industrial use, and major tech companies are investing heavily in platforms that extend beyond individual companies to whole industries.

One aerospace company struggling with supply issues combined data from purchasing, part tracking, and inventory monitoring in a single platform to enable real-time visibility of each part across the entire supply chain. The results exceeded expectations, with a 20 percent improvement in procurement productivity and a 5 percent improvement in on-time delivery. Another aerospace company took part traceability to the next level by introducing digital tagging. Parts were automatically scanned for minute differences in surface texture at key points in the supply chain, virtually eliminating counterfeiting and ensuring regulatory adherence.

Intelligence

Advanced analytics and artificial intelligence can be applied to large data sets to generate new insights and enable better decision making in predictive maintenance, quality management, demand forecasting, and other areas. Machine-learning algorithms are growing more powerful as computing power advances and big data proliferates. However,

the full potential of artificial intelligence has yet to be captured in production environments, which at present use only a small fraction of data for decision making.

One auto manufacturer had difficulty managing growing complexity in its product variants, and sought to improve and automate its decision making. To do so, it installed an enterprise manufacturing intelligence (EMI) system that ingested data from more than 400 IoT sensors, enabling predictive intelligence to be applied to maintenance, quality, and parts supply. Introducing the new system improved overall equipment effectiveness by 10 percent and first-time-right delivery by 15 percentage points.

Flexible automation

Robotics and automation have been commonplace in industrial manufacturing for decades, but we are seeing a new wave of opportunity driven by declining technology costs, growing functionality, and an expanding range of environments in which robotics can be safely and effectively deployed. Introducing new robotic technologies in product assembly, warehousing, and logistics can improve the productivity, quality, and safety of operational processes. Applications include autonomous guided vehicles in distribution centers, automated warehouse management systems, and cobots (collaborative robots) working on assembly processes in conjunction with humans. Estimates suggest that 60 percent of manufacturing tasks could be automated, but industrial robots have yet to achieve widespread penetration even among early adopters. South Korea, for instance, has only 530 robots for every 10,000 production workers.

Deploying automation across the entire product assembly process from material handling to quality testing and packaging enabled one electronics company to reduce direct and indirect labor costs by

more than 80 percent. These savings in turn allowed the company to manufacture its product in higher-cost countries located close to attractive markets, thereby reducing shipping costs while increasing customer responsiveness and speed to market.

Examples of what connectivity, intelligence, and automation might look like at an aerospace manufacturer are illustrated in Exhibit 3.

Overcoming pilot purgatory

McKinsey's research shows that most advanced industrial companies are conducting pilots in all three of these areas (Exhibit 4). In the aerospace and defense sector, for example, all of the top 10 companies and two-thirds of the top 50 have

announced digital initiatives of some kind. Most of the business leaders we spoke to recognize that technology can help them navigate complex risk and regulatory environments, make their operations more efficient, and enhance the customer experience they offer.

However, advancing beyond the pilot phase is still a big challenge for most manufacturing companies. Even among those reporting significant numbers of pilots, most struggled to achieve broader rollout. In fact, the gap between piloting and rollout is considerably larger than that between perceived relevance and piloting, suggesting that scaling is a bigger hurdle than getting the ball rolling in the first place (Exhibit 5).

EXHIBIT 3 Examples of digital manufacturing innovations at an airline manufacturer

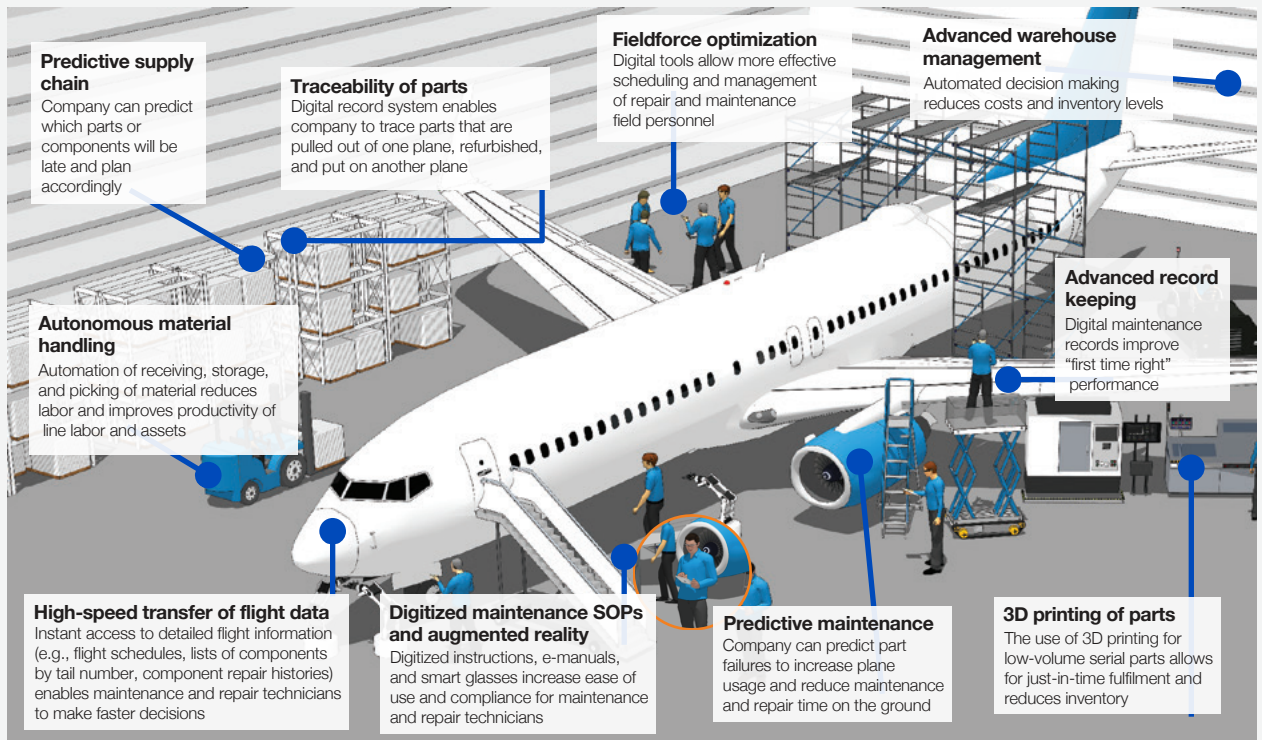
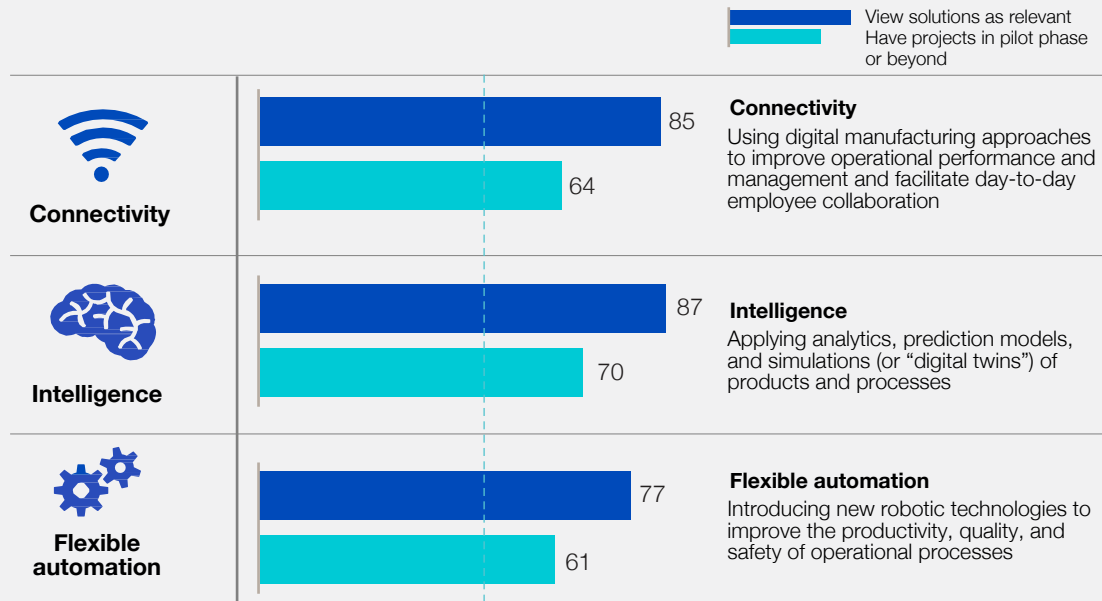


EXHIBIT 4

Most survey respondents regarded digital manufacturing as relevant, and many had pilots under way

Percent of respondents piloting digital manufacturing solutions or viewing them as relevant,

N = 700



Source: McKinsey Digital Manufacturing Global Expert Survey 2018

What we learned from our research—and found reinforced by our client experience and industry observation—is that companies often make the same few mistakes when defining and implementing strategies for technology-enabled transformation in manufacturing and delivery. As a result, they struggle to move beyond what we call “pilot purgatory” and fail to capture sustainable impact at scale. Fortunately, we also found a few real-world examples of companies that achieved effective roll-out by paying close attention to a handful of success factors. These “lighthouse” cases provide inspiration for other manufacturers in developing a vision for how technology can create value, building a solid business case, and charting an effective course for enterprise-wide implementation.

Our research identified six success factors that fall into three categories: strategy, infrastructure, and organization (Exhibit 6).

Strategize the transformation process

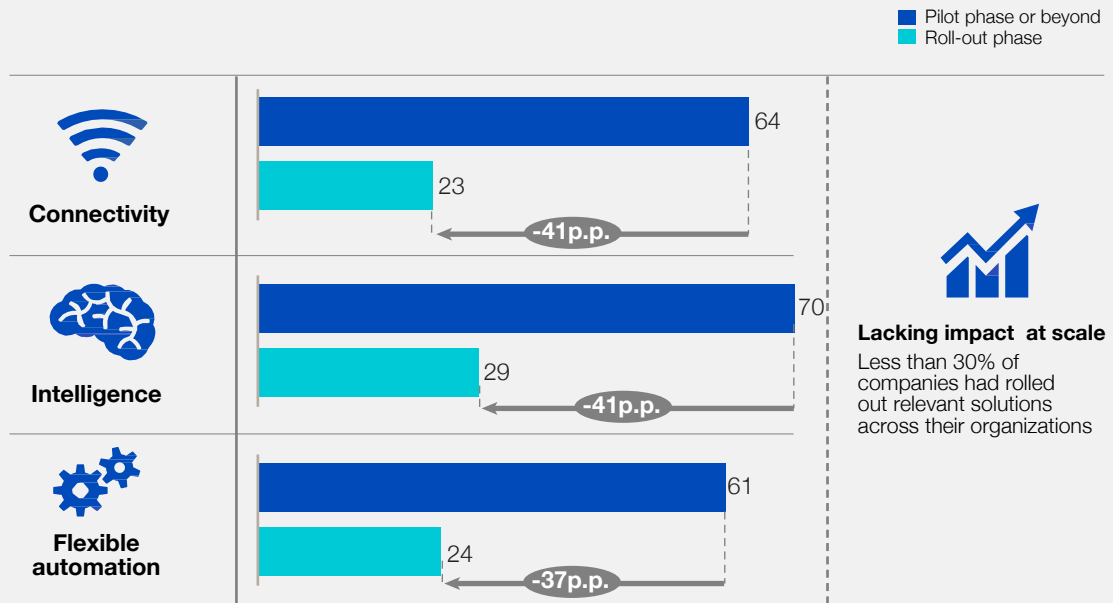
Too many organizations pursue a digital manufacturing journey that ultimately fails to create enough value to justify the cost, time, and management attention involved. To avoid this fate, successful companies establish a solid business case built on two principles:

Start from bottom-line value and work back. With so many digital manufacturing solutions on the market, it’s easy—but dangerous—for companies to get sidetracked by what looks exciting. To deliver tangible results, they need instead to begin with

EXHIBIT 5

Answer to question: what stage has your company reached in adopting digital manufacturing?

Percent of solutions applied; percentage point difference



Source: McKinsey Digital Manufacturing Global Expert Survey 2018

a clear view on how these solutions can address operational pain points, create competitive advantage, and drive bottom-line impact. For some companies, for instance, 3-D printing enables competitive differentiation through leading-edge designs that would be impossible to manufacture in any other way; for others, it is no more than an expensive distraction. As a rough guide, asset-heavy companies would be well advised to treat predictive maintenance as their top priority, while labor-heavy companies should focus on digital performance management.

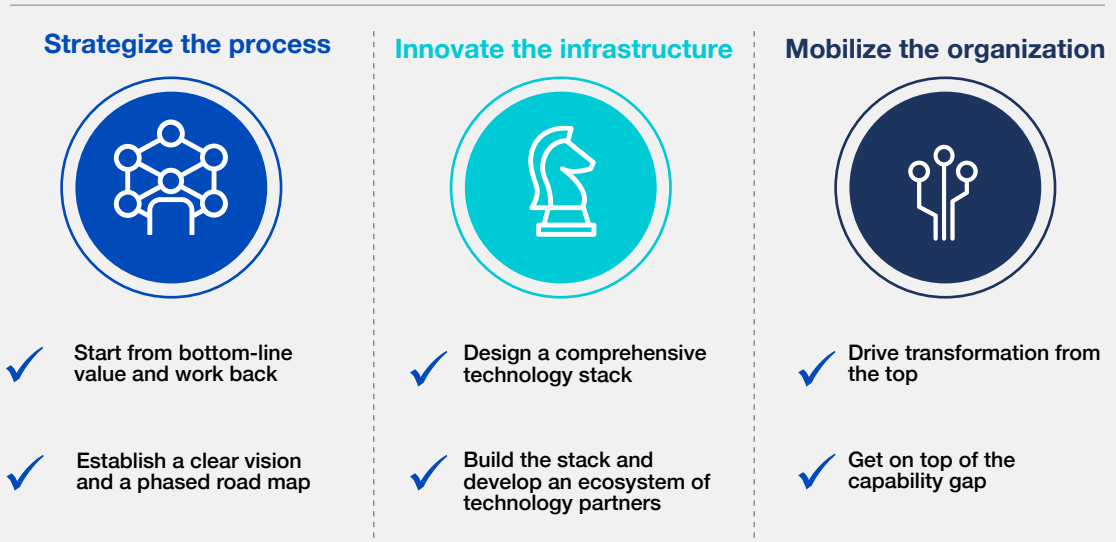
Establish a clear vision and a phased road map.

More than half the respondents in our survey (59 percent) saw lack of vision as a significant obstacle to digital transformation, up from just 15 percent

reported as recently as 2017. Three principles can help manufacturing companies create a vision for digital manufacturing:

- *Think holistically across the ecosystem over the long term.* Spot solutions may generate excitement to fuel broad-scale change, but tend to leave value on the table. Look past the immediate fix and your own capabilities to develop sustainable solutions that build long-term competitive advantage
- *Showcase early wins to solidify buy-in.* However compelling the vision, it will fail without widespread organizational support. Create one or more “lighthouse” facilities to demonstrate how individual use cases reinforce one another to transform outcomes.

To escape pilot purgatory, organizations should act on six key success factors



- **Create an ROI roadmap.** Scaling up calls for careful management of technologies, use cases, process changes, cultural shifts, and investments. To navigate these complexities, create a road map informed by the size and nature of the business opportunity and your requirements for IT and OT architecture and resources.

Innovate the infrastructure

Having addressed strategy and business benefits, companies can then turn to the critical elements of technology stack and ecosystem.

Design a comprehensive technology stack. Almost half (44 percent) of survey respondents regarded IT deficiencies as a major challenge in implementing digital manufacturing. In defining your optimal technology stack, bear five watchwords in mind:

- **Comprehensive.** Ensure your stack spans collection, connectivity, data, analytics, and applications, and is specific to your operational model.
- **Scalable.** Your stack must enable rapid scaling and support future growth. Pay particular attention to your data-ingestion pipeline and complementary analytic capabilities.
- **Analytics-enabled.** Software and infrastructure systems provide the raw material, but analytics produces the insights that generate value. Only 20 percent of organizations have a data lake that covers more than half their plants, and only 25 percent use an advanced analytics platform at scale. Companies that integrate their data and extract more insights from it will create more value.

- **Integrated.** Integrate data from IT and OT to help you develop digital-manufacturing use cases that meet your business needs.
- **Secure.** Address cybersecurity at every step, taking special care over the connections between legacy and future systems.

Build the stack and develop an ecosystem of technology partners.

Every stage of the process, from developing a technology stack to rolling it out, must be tightly managed to ensure cohesion and seamlessness. We recommend following three guidelines as you move forward:

- **Minimize architecture complexity.** Navigating the complex landscape of solution providers presents many challenges. When building components into your technology stack, make as much use of industry standards as possible to ensure interoperability across the organization.
- **Use external partnerships to access functional and integrative expertise.** Select a few partners with deep functional and integrative expertise and develop solutions with them where possible. Our research shows that more than 40 percent of organizations are either building their own IT/OT systems in house or tailoring externally sourced systems to their needs, creating a wide range of systems that need to be bridged. The right partners can help you ensure seamless integration and functionality.
- **Drive agile execution across organizational silos.** As well as forging external partnerships, break down organizational silos and build your own capabilities for collaborating across functions.

Mobilize the organization

Digitizing an entire production system requires tremendous change that goes well beyond

technology. People are critical to success, and harnessing their energies requires you to:

Drive transformation from the top. Capturing the full potential from digital manufacturing calls for a consistent approach in which you:

- **Ensure executive-level leadership and P&L commitment.** Appoint an executive-level transformation leader to drive digital manufacturing—something that only about a third of manufacturers have done so far. Consider taking your whole top team to digital immersion sessions and “go and see” visits to understand the new capabilities and ways of working you will need to develop. Accelerate the pace of your transformation by committing P&L to the effort.
- **Integrate decision making across countries and functions.** Any fragmentation in the way you apply digital technologies could jeopardize the success of your transformation. Coordination across plants, locations, and functions along the value chain is essential, yet far from universal: only a third of companies report having a globally coordinated digital-manufacturing effort.
- **Get on top of the capability gap.** To foster an organizational culture that facilitates individual and team development:
- **Encourage innovation.** Create an environment that promotes creativity and innovation to give your transformation the best chance of success. Consider launching an innovation challenge for your organization, ecosystem, and academic partners to generate ideas and allow you to co-create new offerings with suppliers and external experts.
- **Focus on talent.** More than two-thirds of companies see attracting, managing, and

retaining top talent as the biggest challenge in implementing digital manufacturing. Secure the capabilities you need by combining in-house training with hiring from outside and collaborating with solutions providers, research institutions, and academics.



A holistic approach to transforming manufacturing through technology involves the fundamentals of your organization and your business as much as the technologies themselves. Following the guidelines suggested in this article will help you accelerate implementation, bridge the gap between pilot success and enterprise-wide roll-out, and unlock new sources of value. ■

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