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Operations Practice

Industry 4.0: Reimagining manufacturing operations after COVID-19

Industry 4.0 technologies were already transforming manufacturers' operations before the pandemic. Now adoption is diverging between technology haves and have-nots.

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Even in parts of the world where COVID-19's initial effects have started to recede, serious dislocations appear likely to remain a fact of life for some time to come, with executives constantly facing new pressure. In a recent McKinsey survey of manufacturers in Asia, for example, struggles with sudden materials shortages were a common issue (reported by 45 percent of respondents), along with steep drops in demand (41 percent), and worker unavailability (30 percent).

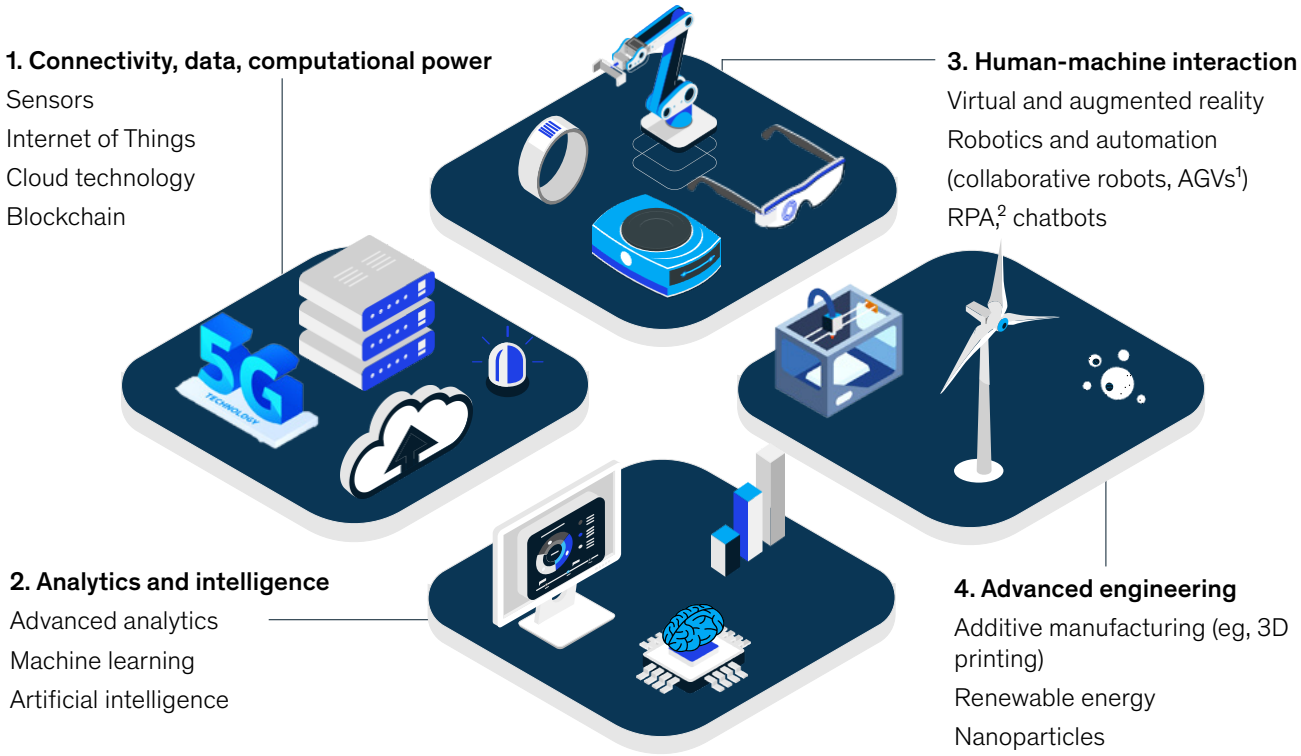
Yet volatility was becoming a watchword among supply-chain and manufacturing leaders even before the pandemic. As businesses adjust to the next normal, executives are grappling with the longer-term question: How will manufacturing and its supply chains look after COVID-19?

Most important, they are likely to be much more digital, as is already evident in the immediate response to the crisis. Industry leaders are leveraging Industry 4.0 solutions: 39 percent have implemented a nerve-center, or control-tower, approach to increase end-to-end supply-chain transparency, and around a quarter are fast-tracking automation programs to stem worker shortages arising from COVID-19.

"Acceleration" is the watchword. Industry 4.0—which includes connectivity, advanced analytics, automation, and advanced-manufacturing technologies (Exhibit 1)—was gaining momentum before COVID-19, helping companies transform their operations in everything from production efficiency to product customization, with improvements in speed to market, service effectiveness, and new-business model creation.

Exhibit 1

Industry 4.0 is characterized by 4 foundational technologies applied along the value chain.



[1]Autonomous guided vehicles
[2]Robotic process automation

Two-speed adoption of Industry 4.0 technologies

But the role of Industry 4.0 becomes even more critical in the backdrop of a crisis such as COVID-19. Players utilizing digital solutions are better-positioned to weather the storm, having moved faster and further than their peers during the crisis.

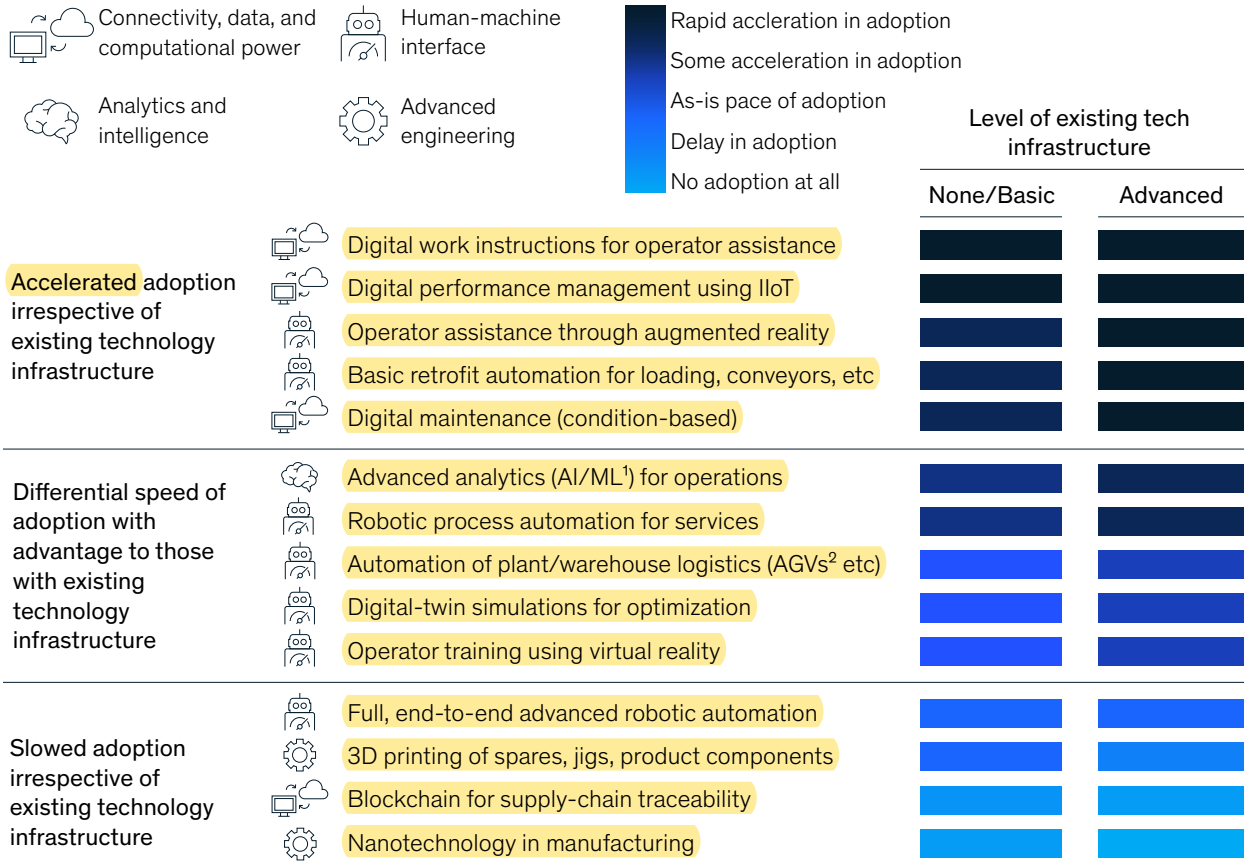
As companies think about restoring operations and building the muscle to deal with future crises, using digital technologies will be top of mind for many. A recent McKinsey survey of manufacturing and supply-chain professionals found that 93 percent plan to focus on resilience of their supply chain, and 90 percent plan to invest in talent for digitization.

However, the upswing in technology adoption could be asymmetric because of two opposing forces— the need to develop resilience and agility to deal with the crisis, against the constraints imposed by cash preservation. Three archetypes of adoption pathways appear likely to emerge.

Accelerated adoption for quick-win solutions that help companies respond and adapt to the new norms —such as tracking employee health, enforcing safe distancing on the shop floor, and supporting remote collaboration. Digital work instructions, augmented reality–based operator assistance, and use-cases relying on simple, inexpensive retrofit automation may also become more widespread regardless of companies' existing technology infrastructure (Exhibit 2). Digital performance management (DPM), for example, has been a popular early use case at a wide range of companies, including several small precision-engineering companies where pilots of DPM have helped boost productivity by 40 to 70 percent.

Exhibit 2

Some Industry 4.0 moves can be accelerated without major technology investments.



[1]Artificial intelligence/machine learning
[2]Autonomous guided vehicles

Differential adoption rates are more likely for solutions such as digital twins and logistics automation, which fall into a middle category requiring foundational information technology (IT), operations technology (OT), and data infrastructure. Companies that already have the critical capabilities, such as manufacturing-execution systems, IT/OT stacks, and data marts or data lakes, may speed ahead, while organizations lacking these prerequisites—particularly small and medium enterprises (SMEs) and businesses in a more challenging financial or liquidity position—may delay implementation until they are able to build the foundations or find the required financial muscle to invest.

Several automation technologies are already seeing a split in adoption. Historically, manufacturers in China have been about three times as fast as those in other regions to deploy industrial robots. That momentum seemed to have tapered off in the first quarter of 2020, when robot sales in China fell by 20 percent compared to the same period in 2019. Yet in our recent survey, more than one-third of respondents in China said their companies were accelerating automation initiatives, in contrast to only 16 percent of their counterparts in the rest of Asia, and 18 percent the rest of the world.

Deferred adoption is more likely for solutions that require higher capital expenditure and have unclear or long-term payback periods. Examples include blockchain, nanotechnologies, and the most advanced automation systems.

A resilient, digitized future beyond the factory's four walls

Companies can deploy digital solutions beyond the four walls of a manufacturing plant, reaching across the end-to-end value chain to address planning (and replanning) challenges related to disruptions at suppliers or production plants, operational challenges in managing workplace health risks, and delivery challenges posed at transportation modes or in warehouses.

Planning for operations

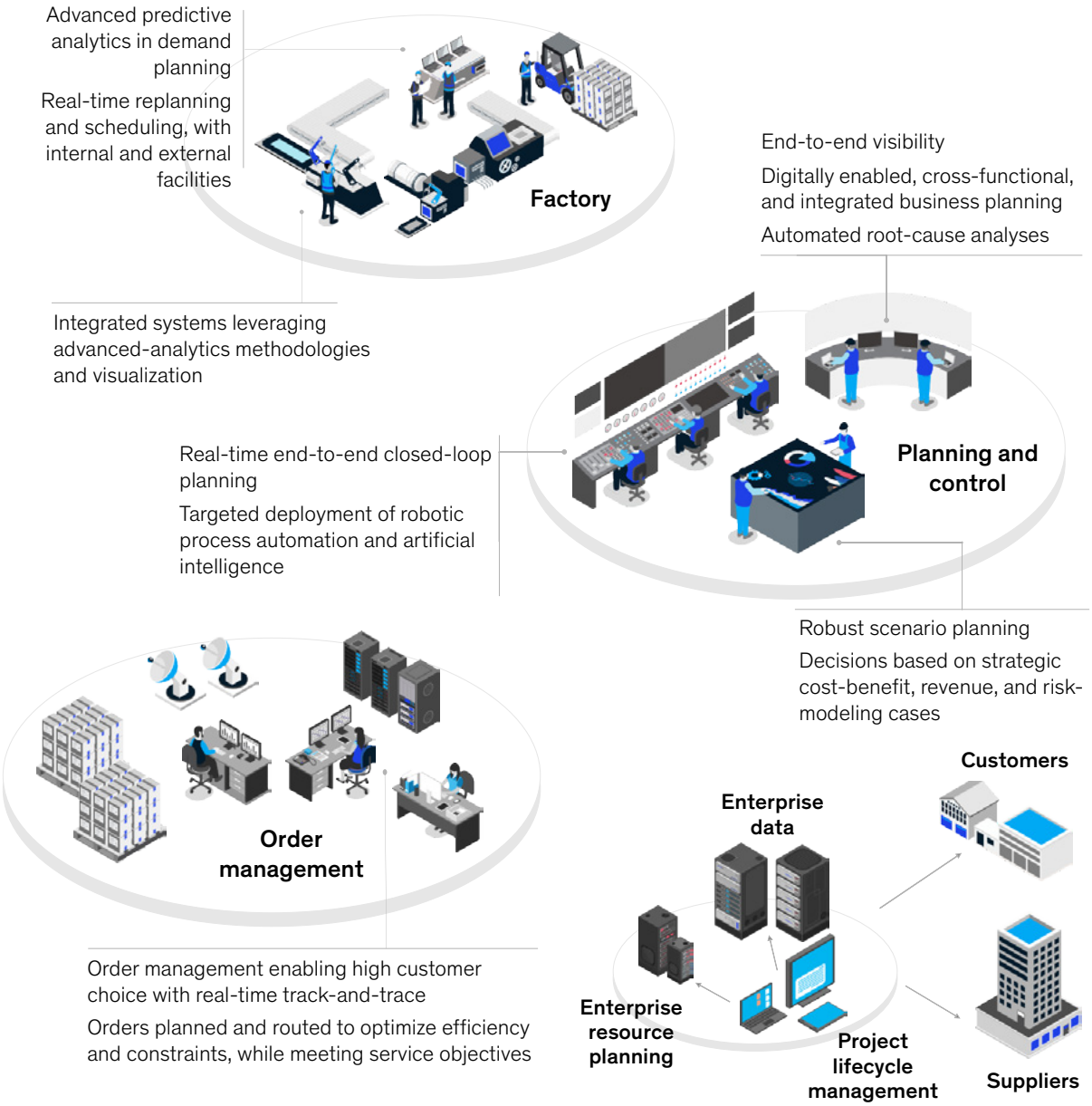
A core element of manufacturing and supply-chain operations—planning—has traditionally been conducted in silos, with demand forecasting, supply planning, production planning, logistics planning, and sales and operations planning (S&OP) all handled by separate teams. Interrupted global trade flows and value chains have forced companies to break the silos to improve end-to-end visibility. As a result, the potential impact from optimized planning is more evident. But it also requires a more sophisticated analytical approach, and collaboration across multiple functions and stakeholders.

Consider demand forecasting. Traditional forecasting algorithms rely on relatively simplistic statistical tools to extrapolate previous demand, based on the assumption that the relationship between independent variables (such as previous sales) and dependent variables (future demand) will likely remain unchanged. Moreover, companies usually have used only internal data, perhaps in combination with past sales trends and customer signals for future orders. An external shock at COVID-19's scale cripples such a traditional demand-forecasting process.

In contrast, autonomous planning relies on artificial-intelligence and machine-learning algorithms, which are supplemented not only by internal data, but also by external datasets from suppliers, customers, weather forecasters, demographic sources, and broader economic indicators. Incorporating these additional variables helps organizations respond to changing dynamics and external shocks more effectively. Advanced analytics can also optimize planning across the entire value chain in a way that wasn't feasible under a siloed approach with traditional analytical tools (Exhibit 3).

Exhibit 3

Planning 4.0 turns analytics and artificial intelligence into flexible, responsive operations.



A European consumer-goods manufacturer invested in a single customer-to-supplier demand-supply data system that integrated end-to-end demand sensing into their sales and operations planning process.

Automotive and industrial-goods manufacturers have connected to supplier data through modernized electronic data interchange (EDI) for a better crisis-response planning.

A global consumer-goods manufacturer used advanced analytics and trend data from the eruption of COVID-19 cases to generate a detailed model of its Asian operations that were most affected by the pandemic. By creating a digital twin of its supply network, the manufacturer could predict customer and supplier behavior about 10 days in advance, providing ample lead time to respond with countermeasures and adjustments to production plans, with resources reallocated as needed.

Making the products

The manufacturing disruptions from COVID-19 stem from many sources, ranging from safe-distancing measures and staggered worker attendance to restricted migrant-labor movement within and between countries. Digital technologies can help mitigate the effects in multiple ways, boosting employee safety, operational efficiency, asset productivity, and product quality.

Boosting employee safety and operational continuity

Digital technologies that enable remote work and collaboration, eliminating the need for noncritical employees to leave their homes, are becoming a necessity. Beyond basic contact- and location-tracing mobile apps and videoconferencing applications, more advanced solutions, such as machine-vision algorithms and wearable technologies, are also helping maintain safe distancing as manufacturing operations restart.

Improving productivity and performance management

In most companies, and especially SMEs, data collection is manual, using pen and paper or basic spreadsheets. The process is prone to errors and inaccuracies, which are naturally exacerbated during the stress of a crisis. Digital solutions allow manufacturers to automate data collection by adding sensors or directly tapping into machines' programmable logic controllers (PLCs) to collect data and display it on live dashboards.

Supervisors can then monitor factory performance remotely and in real time. They can deploy interventions when needed, conduct effective performance-management meetings, adapt daily plans to meet customer demands, and to improve labor productivity as well as operational efficiency—all remotely.

In addition, process automation and physical automation or robotics can supplement labor capacity. In some instances, "brownfield" automation of existing operations has become a more attractive way to manage worker shortages and minimize potential business losses due to unmet orders. At one industrial manufacturing company, robots are now delivering raw materials and semi-finished goods to different production lines—helping the production team cope with a reduced workforce while preventing close contact between production and material-handling employees.

Increasing asset utilization and efficiency

Wearable technologies, such as augmented-reality glasses, can enhance remote assistance in maintenance, such as when operators need off-site assistance due to limitations on travel. This increases machine availability by reducing maintenance downtime.

Similarly, automated equipment-monitoring and process-control systems can bolster the continuity of operations, even with skeletal crews. These systems can further optimize operating-equipment and process parameters, increasing overall equipment efficiency for reduced cycle times and higher yield, quality, energy, and throughput—an especially attractive prospect for continuous-process industries where process parameters must be constantly monitored and optimized.

Improved quality

Beyond improving day-to-day operations, digital technologies can go one step further in quality management. For example, machine-vision algorithms can conduct automatic quality inspection and quality control using predictive algorithms, relieving constraints in workforce availability while increasing the precision and threshold of quality checks. Furthermore, as SKU counts increase for finished products and raw materials, ensuring end-to-end traceability becomes increasingly important for quality. Industry 4.0 technologies, from simple barcode scanning to RFID tracking and blockchain, can help (Exhibit 4).

Exhibit 4

Manufacturing 4.0 uses automation to improve quality, safety, and productivity.

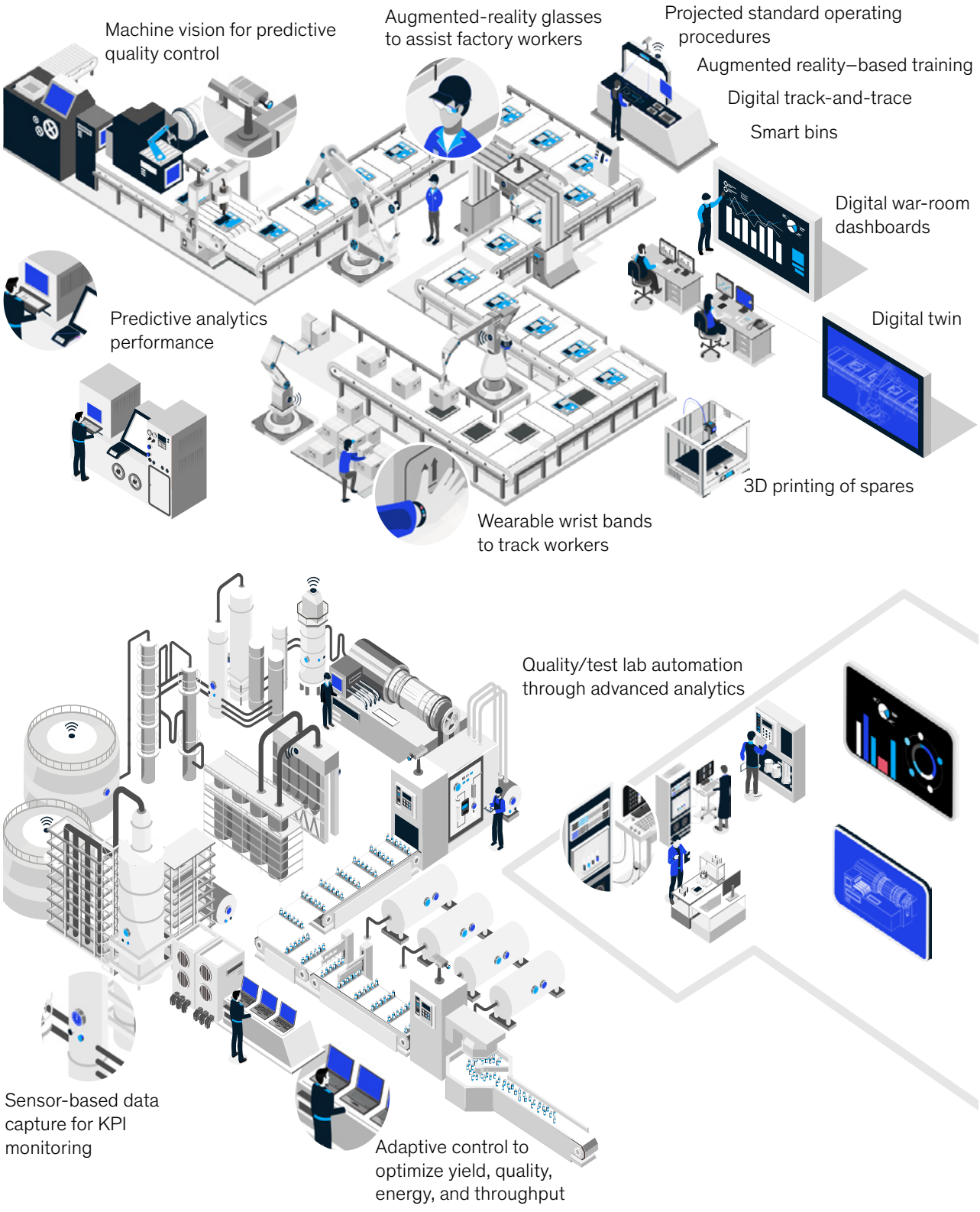


Exhibit 4 cont.

- A global consumer-goods company enabled complete remote management of its sites through integrated end-to-end performance dashboards
- Small and medium enterprises in Southeast Asia are using bolt-on IIoT kits to digitize data collection and visualization
- A major electronics manufacturer is accelerating its automation projects to help decrease contact between employees

A personal-protective-equipment manufacturer managed to expand production capacity during COVID-19 by leveraging virtual-reality glasses to expedite the final commissioning phase of their new manufacturing line. The remote-assistance and augmented-reality features were able to overcome travel restrictions and help to ensure the safety of its workforce.

A medical-devices manufacturer implemented adaptive process control, together with advanced-analytics capabilities and enhanced data infrastructure, to create additional production capacity dedicated to accelerated new-product development and new production volumes. Production lines were upgraded with IIoT-enabled, fully validated closed-loop adaptive process controls, with advanced robotics and intelligent material handling. Results include higher yield, reduced downtimes, increased overall equipment effectiveness and faster time to scale.

Delivering the finished goods

Delivering the finished goods to customers is a complex, dynamic task that often involves third-party logistics partners. The COVID-19 crises reduced availability of transportation modes while introducing added complexities, such as new requirements for packaging and for safe, last-mile contactless delivery. In this context, digital and analytics solutions can increase visibility of both demand and supply for logistics services, improving real-time performance.

Logistics

A digital logistics-control tower can create live visibility into performance at every stage of outbound logistics, from loading in the warehouse to unloading at the delivery point. Combined with digital fleet management, route optimization, and carrier analytics, these tools can raise uptime for transportation assets while optimizing the operation, management, and allocation of resources. Collectively, these changes can go a long way toward increasing operational resilience in responding to crises.

Warehousing

Warehouses present many opportunities for a automation interventions. These include shuttle systems, automated material-storage and retrieval systems, smart shelves, smart picking robots and cobots—and automated and intelligent sorting, picking, and packing systems, along with drones to perform inventory inspection. A digital twin can help design optimal warehouse operations, creating a digital duplicate of a warehouse to understand the results available from different digital technologies. Other Industry 4.0 solutions can assist warehouse workers as well, including augmented-reality tools that make picking multiple orders at one go much easier and more effective, and exoskeletons to reduce injury from repeated heavy-material handling (Exhibit 5).

Exhibit 5

Delivering 4.0 gets products to customers on-time, in-full, and at the right cost.

Real-time location data from moving trucks translated by analytics into actionable insights (eg, possible late deliveries to customers), thereby:

- Improving on-time service
- Reducing transportation cost (increasing fleet utilization)

Fleet management

Telematics and on-board sensors, combined with machine learning, help influence driver behavior and enable predictive maintenance to:

- Increase fleet fuel efficiency
- Reduce maintenance cost (by reducing equipment failures)
- Minimize asset downtime

Dynamic network-flow design optimizes load routing during weekly planning, reducing transportation cost by:

- Minimizing empty miles in backhaul and dead haul (help avoid surge charges)
- Reducing minimum charges due to extended distances

Carrier analytics

Advanced freight-sourcing decision-support tool for third-party procurement award and control

- Ongoing lane value-assessment and bid-scenario analysis
- Route-guide compliance and individual carrier performance assessment

Digitized and automated warehouse

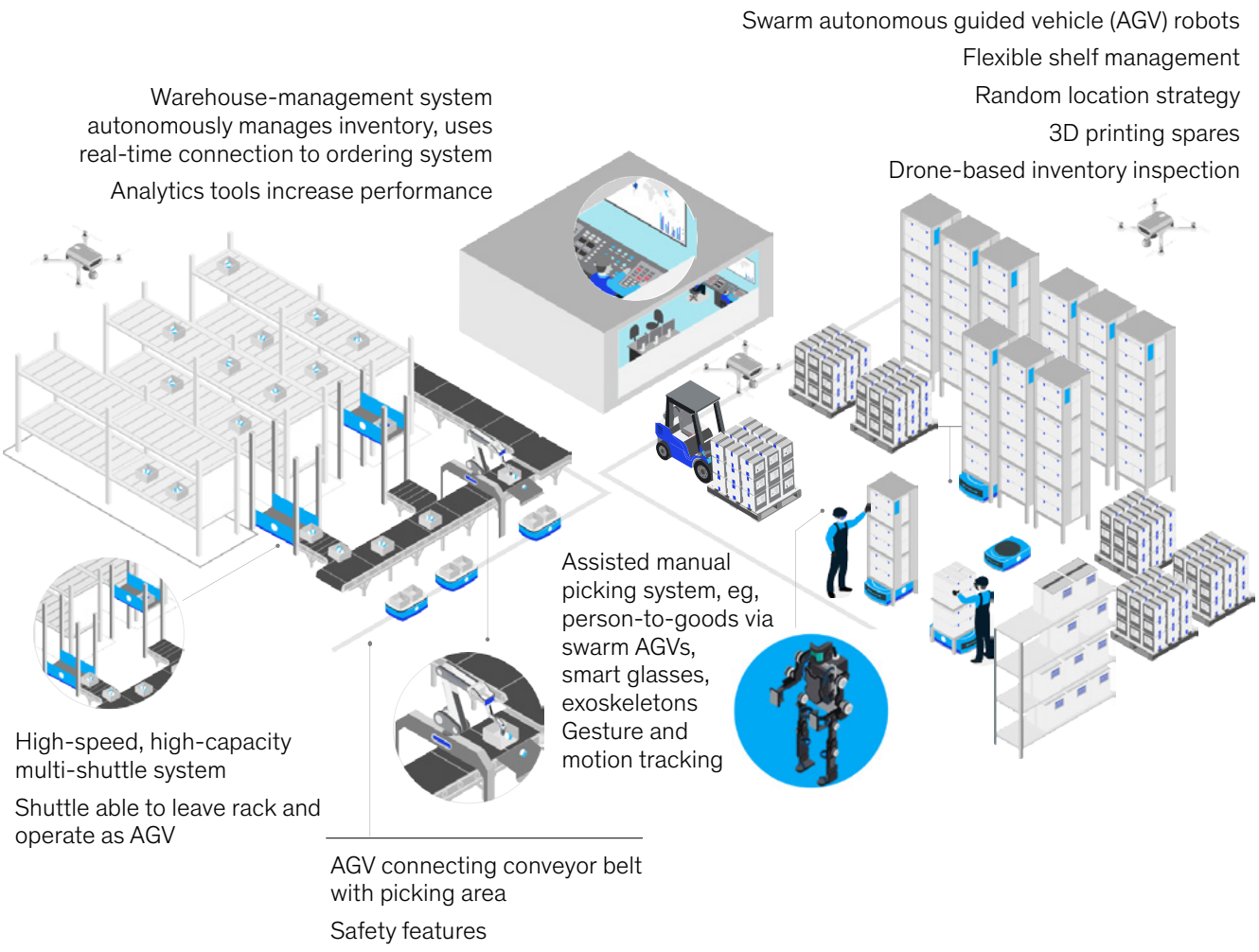


Exhibit 5 cont.

An industrial manufacturing company transformed its entire delivery operation, including setting up analytics that feed into a dashboard providing daily visibility of transit times for air and ocean shipments, thus improving on-time delivery. During COVID-19 the dashboard helped proactively identify potential delivery misses, suggest actions to remove delays, and accurately plan for goods arrival at customer locations. And an automated, digitized carrier scorecard helps identify which carriers are under-performing against their target service levels.

A global logistics company invested in creating digital twins of its warehouses, enabling it to design a storage mechanism that minimizes retrieval time and cost, while using a swarm of picking robots and inventory-inspection drones to eliminate manual intervention.

A medical-devices manufacturer plans to implement automation at its largest distribution center to reduce manual work by 50 percent and more than double productivity in pick, pack, and ship. It plans to use technologies such as AGVs, mobile robots, and reconfigurable storage mechanisms.

A triple transformation recipe for Industry 4.0

Before the outbreak of COVID-19, there was widespread excitement on Industry 4.0, with 90 percent of respondents in McKinsey's annual Industry 4.0 survey saying that they were convinced of the technologies' value—and a majority of them including Industry 4.0 as a critical part of their operational-improvement planning.

The potential asymmetry in adoption in the wake of the pandemic has caused some companies to freeze their Industry 4.0 initiatives to preserve cash, even as certain leaders have accelerated their adoption, particularly of use cases for supporting business continuity—such as automated planning, digital performance management, digital remote work, and automation to reduce human-to-human interaction. Consequently, as more businesses emerge from the crisis, the case for further digitization at scale will likely be stronger than ever.

Yet transformations at scale are difficult. Our research—stretching back more than a decade—indicates that about 70 percent of such initiatives fail to achieve their stated objectives.

Our most recent survey of Industry 4.0 sentiment, conducted in late 2019, found that after starting their Industry 4.0 journeys, most companies remained stuck in a pilot trap: only 44 percent were conducting site-wide implementation, and only 38 percent were looking at horizontal integration beyond the four walls of the factory.

Nevertheless, there are reasons to be hopeful as well, for both SMEs and MNCs. A collaboration by the World Economic Forum and McKinsey has identified 44 sites around the world as Industry 4.0 "Lighthouses": manufacturing sites where digital technologies were implemented at scale, and with significant operational impact. Among this group, 14 sites were designated as end-to-end Lighthouses, having digitized along the entire value chain from suppliers to manufacturing, then logistics and eventually customers.

Lighthouses include big and small companies, located in both developing and developed economies, and include greenfield and brownfield locations alike. A common point among them is to have approached their journey from a holistic perspective—a "triple transformation" around business, technology, and organization.

Business. The first step is a clear articulation of the company's desired future state, which is linked to business strategy and goals rather than the technology with the greatest buzz. Selection of use cases for pilots is based on a favorable business case, to be refined as the pilots are implemented.

Outlining a clear business case becomes more complicated when expanding beyond the four walls of the factory, but is even more important. For example, supply-chain integration reaps savings when factoring in hidden costs that often are not explicitly accounted for. Understanding these issues helps organizations formulate a positive business case that will convince suppliers to embark on an integration journey.

Technology. Many, if not most, companies will want to assess their current IT and OT systems, upgrading them to deliver the horsepower that advanced use cases in digital and analytics depend on—particularly to support the Internet of Things. A scalable, obsolescence-resistant IT stack is essential. Similarly, upgrades of suppliers' IT/OT systems might be required for end-to-end horizontal integration of data.

For upgrading the IT/OT tech stack and implementing multiple use cases, companies can leverage external technology providers by creating an ecosystem of partners that can help them execute the digital transformation. Partnership models can vary among outsourcing, acquisitions, and strategic alliances, with successful ecosystems integrating a mix of start-ups and established technology and service providers.

Organization. Few digital transformations can succeed without putting people at the center. Four factors provide crucial support.

— *Governance.* A digital transformation without a clear owner can end up as an orphan. A cross-functional team and governance structures then help ensure quick execution.

— *Top-management commitment.* Transformations are more likely to take hold when they are driven by top leaders, with a compelling change story to help mobilize the organization. To keep momentum from flagging, leaders can celebrate quick wins—as well as failures that help the company learn to fail fast and learn fast.

— *Digital capability acquisition.* Skills gaps can be addressed by hiring where necessary, as well as by upskilling existing employees to fulfill even advanced digital roles, such as analytics translator, data engineer, data scientist, or IoT architect.

— *New ways of working.* Implementing agile working methodologies empowers teams with the tools, processes, and best practices for achieving success in a digital world.

The COVID-19 pandemic has presented humanitarian challenges on a global scale that require a new type of collaboration to address. As organizations begin to restart their operations in the next normal, they have an opportunity to reimagine a future with digitized, resilient operations. Early successes have shown that companies can start on their industry 4.0 journey in a small way and then scale quickly—if they commit to Industry 4.0 transformation in line with their business environment and their strategic objectives, and execute it using a triple transformation approach.

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