Top 10 Strategic Technology Trends for Manufacturing Industries: Smart Factory

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The smart factory is an underlying concept of smart manufacturing, digital supply chain and Industrie 4.0. This research shows manufacturing operations leaders how smart factories align with Gartner's Top 10 Strategic Technology Trends and provides guidance on maximizing their potential.

Key Findings

- The smart factory is a concept used to describe the application of different combinations of modern technologies to create a hyper-flexible, self-adapting manufacturing capability. It is an underlying capability of smart manufacturing, which in turn fuels digital supply chain and Industrie 4.0 programs.
- Smart factories align with many of Gartner's Top 10 Strategic Technology Trends. There is no one dominant technology combination for smart factories. Most notably, smart factories are a specific kind of smart spaces where frontline workers and technology interact in an open, connected and coordinated fashion.
- The smart factory concept has risk of creating constraints through projects in isolation. Successful smart factories result from an intense level of orchestration and alignment between multiple supply chain functions (e.g., IT, operational technology [OT] and the CIO's office).

Recommendations

Manufacturing operations leaders seeking to maximize the potential of smart factories must:

- Promote the smart factory concept's role as part of an agile supply system that is integrated and connected to customer demand. This will lessen the risk of establishing success in isolation.
- Unleash innovation potential by running test-and-learns for different combinations of technologies. Identify the ideal technology combinations that align the smart factory with the specific segments it supports. Value stream mapping can play a critical role.

- Sustain big cultural changes by focusing on hybrid teams that blend IT, OT and supply chain functions. This will help the communication, skills development and subsequent scalability.

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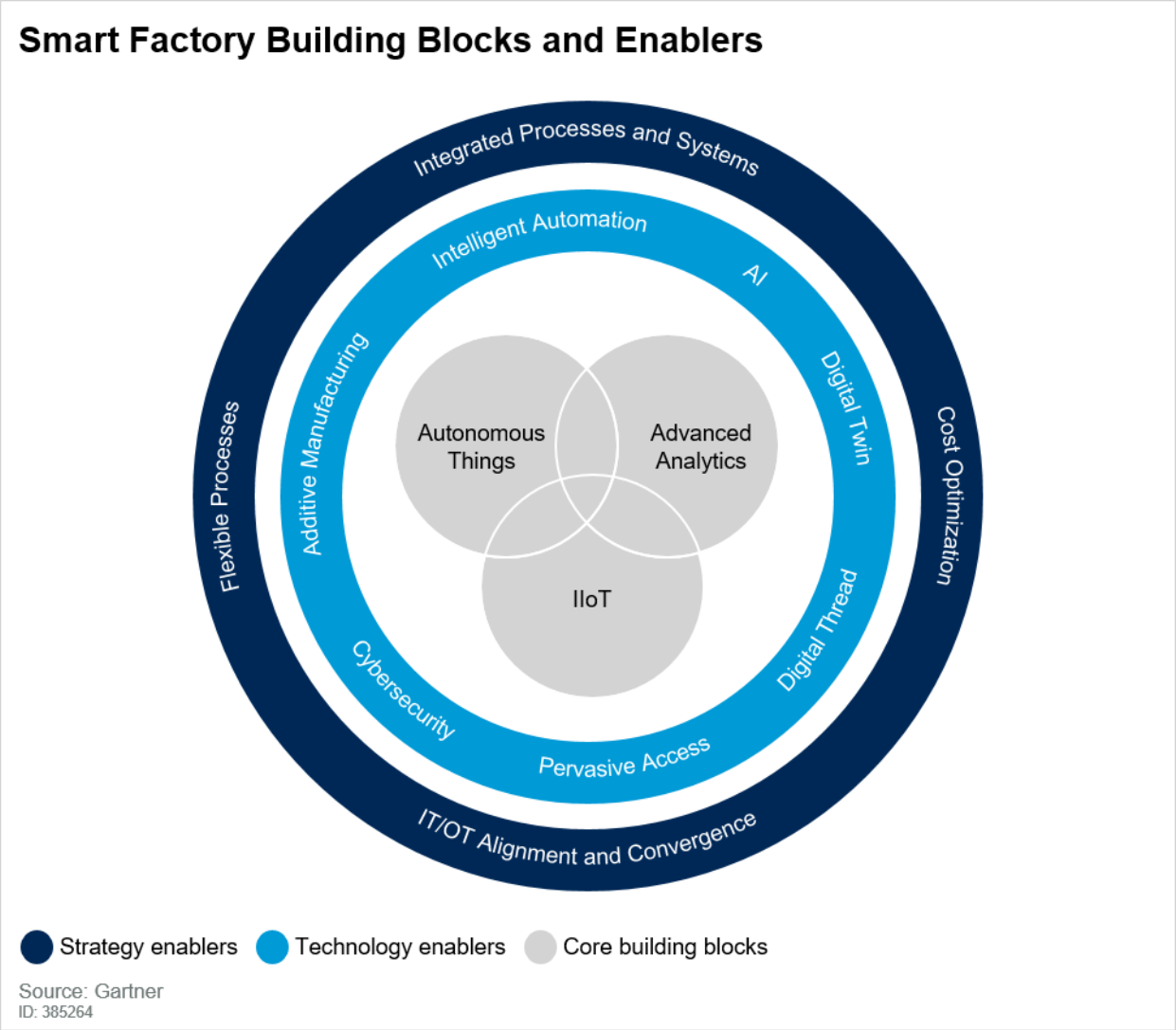
Why the Smart Factory Is a Top 10 Trend

The smart factory is a concept used to describe the application of different combinations of modern technologies (shown in the framework in Figure 1) to create a hyper-flexible, self-adapting manufacturing capability. Smart factories are an opportunity to create new forms of efficiency and flexibility by connecting different processes, information streams and stakeholders (frontline workers, planners, etc.) in a streamlined fashion. Smart factory initiatives might also be referred to as "digital factory" or "intelligent factory."

Smart factories are an underlying concept of smart manufacturing. Smart manufacturing entails orchestrating physical and digital processes within factories and across other supply chain functions to optimize current and future supply and demand requirements. This is accomplished by transforming and improving ways in which people, processes and technologies operate to deliver the critical information needed to impact decision quality, efficiency, cost and agility (see "Harvest

the Value of Smart Manufacturing in the Supply Chain, Not the Factory"). In turn, smart manufacturing is a cornerstone of digital supply chain and Industrie 4.0 strategies and programs.

Figure 1. Smart Factory Building Blocks and Enablers



Smart factory initiatives have captured the attention of manufacturing operations leaders, their supply chain counterparts, and the CIO and their teams. All recognize the concept's fit within broader programs seeking to establish digital supply chains that improve competitiveness and the customer experience through modern and flexible manufacturing capabilities, and are making investments. HP's $74 million Smart Manufacturing Application and Research Centre (Smarc) in Singapore will experiment with different applications of 3D printing, robotics and analytics.[1] The objective is to develop new solutions that improve productivity across its global network of factories.

Many government and/or consortium-led and government-driven industrial productivity initiatives such as Germany's Industrie 4.0 or the U.S.'s Clean Energy Smart Manufacturing Innovation Institute (CESMII) have concentrated efforts to develop and promote robust solutions for manufacturing operations. Some governments are promoting localized manufacturing capabilities in anticipation of diffusing benefits into other economic sectors. (See "More Than Digital Is Driving the Factory of the Future.") In turn, manufacturers are making significant changes to their strategies, advantageously leveraging these initiatives and improving local market competitiveness. For example, ABB will be setting up several smart factories throughout India in support of the nation's "One India, One Common Market" goods and services tax (GST) endeavor.[2] Its first factory will leverage Industrial Internet of Things (IIoT) for the continuous monitoring and visualization of its production processes. Several Korean-headquartered manufacturing conglomerates are productizing solutions which combine AI, IIoT, and advanced analytics to enable smart factories. These include Samsung SDS's Nexplant and LG CNS's Factova. The latter is deployed across several of LG business units worldwide.

Caution: Smart Factory Hype Fuels the Risk of Isolated Production Capabilities

The ultimate state is for smart factories to service varied demand signals (fluctuating order sizes or different product attributes) with minimal downtime, cost, or quality consequences. Not to be overlooked, are the opportunities to simplify the access to and usage of new data through IIoT gateways and edge devices to identify and implement continuous improvement or increasing levels of automation and optimizing productivity levels.

The smart factory concept is at the vanguard of manufacturing innovation, yet its technology heaviness is its greatest risk. Using sensors, immersive experiences and flexible automation could provide return on investment by providing accurate information to improve decision making, shorten changeover times or reduce costs. However, characterizing the smart factory as a technology project to drive manufacturing capabilities at a site or line level devolves away from its potential to support agility, order to cash or new product introduction (NPI). Smart factories must be orchestrated and synchronized with other supply chain functions (planning, logistics and customer fulfillment) to eliminate compromising perfect order performance.

Where Smart Factory Fits in the Top 10 Strategic Technology Trends

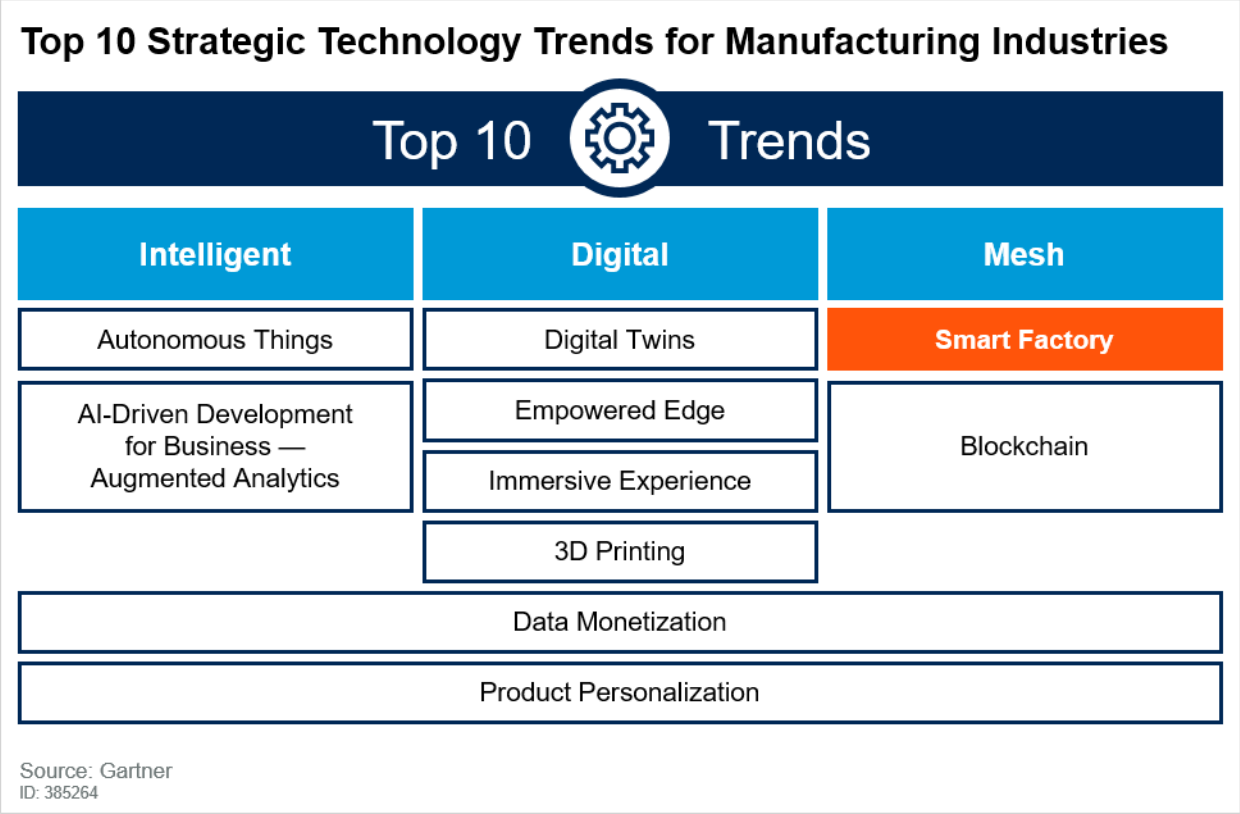
As shown in Figure 2, the smart factory concept is one of the Top 10 Strategic Technology Trends for Manufacturing Industries. More broadly it has several links to many of Gartner's Top 10 Strategic Technology Trends (see "Top 10 Strategic Technology Trends for 2019"). The most notable link is with smart spaces (see "Top 10 Strategic Technology Trends: Smart Spaces"). A smart space is a physical or digital environment in which humans and technology-enabled systems interact in increasingly open, connected, coordinated and intelligent ecosystems. Smart factories can leverage a plethora of technology combinations to dynamically coordinate people, production processes and other aspects of their surroundings (equipment, products) in an immersive, interactive, flexible and automated fashion. Other technology alignments include:

- **Autonomous Things** that supplement existing workers and processes. The increased usage of autonomous mobile robots (AMRs) and various applications of robotics (cobots, robotic arms,

etc.) will exploit AI to intelligently automate processes and support the convergence of smart factories with other supply chain functions. (See “Unify End-to-End Supply Chain Processes With Supply Chain Convergence.”)

- **Augmented Analytics** that use machine learning (ML) driven by IIoT to automate the data preparation, management and analysis of production data can change the speed and efficacy of how operational decisions are made. For long-term, sustained impact manufacturers will have to overcome the shortage of holistic, harmonized and context-based data models. Doing so will move beyond descriptive and diagnostic analytics and improve actionable decisions. There is value to capture in the short term in areas such as process mining and statistical process control (SPC) and visual inspection. (See “Evolve Your Manufacturing Intelligence Strategy to Keep Pace With New Analytics Requirements.”)
- **Digital Twins** powered by the Internet of Things (IoT) are digital representations of physical entities or systems that can shorten the time frames to commission new lines. More imminently digital twins can drastically improve reliability and free up capacity by identifying downtime before it happens. Caveat emptor: Digital twins, particularly those deployed in complex physical environments, rely on data originally created in proprietary formats from multiple disparate sources. Data format incompatibility makes creating, cultivating and using digital twins challenging. The viability and value of digital twins require a data governance strategy. (See “Adopt a Data Governance Strategy for Long-Term Digital Twin Success.”)
- **Empowered Edge** is being driven by IoT and the need to keep processing close to the plant, rather than on a centralized cloud server. However, instead of creating a new architecture and attempt to justify the capital expenditures for “rip and replace,” cloud and edge computing are evolving as complementary models to existing factory systems’ architectures. Inside factories, this creates opportunities to access new data sources (i.e., environmental data) and widen the understanding and knowledge of production performance. More broadly the maturation of 5G can offer a creative way to decentralize manufacturing capacity into mobile factories (see “Supply Chain Brief: ‘Factory in a Box’ Concept Challenges Traditional Factory Setup”). Mobile factories are smaller, portable sites supported by an ecosystem of partners.
- **Immersive Experiences** can change how factory workers perceive the digital world and interact with it. Augmented reality (AR), virtual reality (VR) and mixed reality (MR) will drive future immersive user experiences. Through new interaction models and experiences human capabilities are amplified, and the nature of standard work and how frontline workers execute certain methods and procedures are completely changed. Broadly, the combination of these technologies seeks to create people-literate technologies. In many smart factories there are fast and easily measurable impacts from using AR in maintenance, quality or complex assembly processes. Despite the quick-win potential, the transition of factory workforces toward a level of digital dexterity and adapting to work outside of tribal knowledge could prove challenging in many organizations.

Figure 2. How Smart Factories Fit in the Top 10 Strategic Technology Trends for Manufacturing Industries



Smart Factories Are Delivering Value Across Industries and Geographies Today

Smart factories appeal to all manufacturers, and approaches will differ by industry and manufacturing style. There is no one specific technology or combination of technologies that are embraced. To start their path, some companies are simply satisfied by removing paper from their processes.

No matter what the approach, common traits are the improvements in cost, quality and service levels (through improved asset reliability and recaptured capacity). The following are some examples of the smart factory concept being applied with measurable impact:

- A Chinese white goods producer's burning platform to pursue its smart factory initiative was multifaceted. On one hand, it was compelled to remain competitive in the market as its competitors invested in similar capabilities. On the other, it had to sustain and improve its productivity and quality levels while costs of labor and production varied. The company has invested 5 billion yuan in its initiatives (including using 1,500 robots). Today, one of its plants can make and deliver a product within 12 days of receiving an order.
- Augmented analytics and algorithms are used by a rubber producer to maintain product integrity and limit scrap cost. At one site which produces over 50,000 units per day it has deployed over 2,000 sensors to acquire a greater volume of data from its operations. Algorithms

identify the optimal way to execute processes with the highest variability. This has reduced manual labor, without compromise to productivity or quality levels (which have improved 15%).

- There are many examples of using AR to improve quality and shorten training cycles. In one instance, an automaker is augmenting assembly line workers with cobots to install and calibrate new headlight technologies for adaptive cruise control. The robot takes three seconds to execute the work, removing substantial blocks of time from the process.[3] Another automaker uses autonomous things and it has reduced inventory storage by 60%.
- Siemens Electronics Works facility in Amberg, Germany, uses autonomous things, empowered edge and immersive experiences to produce many of the industrial automation components. It operates 75% of its production processes lights out (including equipment setups and 350 changeovers per day). Much of the automation is done through a complex web of conveyors that route materials throughout the factory on 10-minute replenishment cycles. On average, there are 4,500 transports a day, across 1,000 different checkpoints, enabling the plant to produce over 120 product variants per day. AR is used for the quality control activities that require human intervention. The site maintains a 99.9% built-in-quality metric.

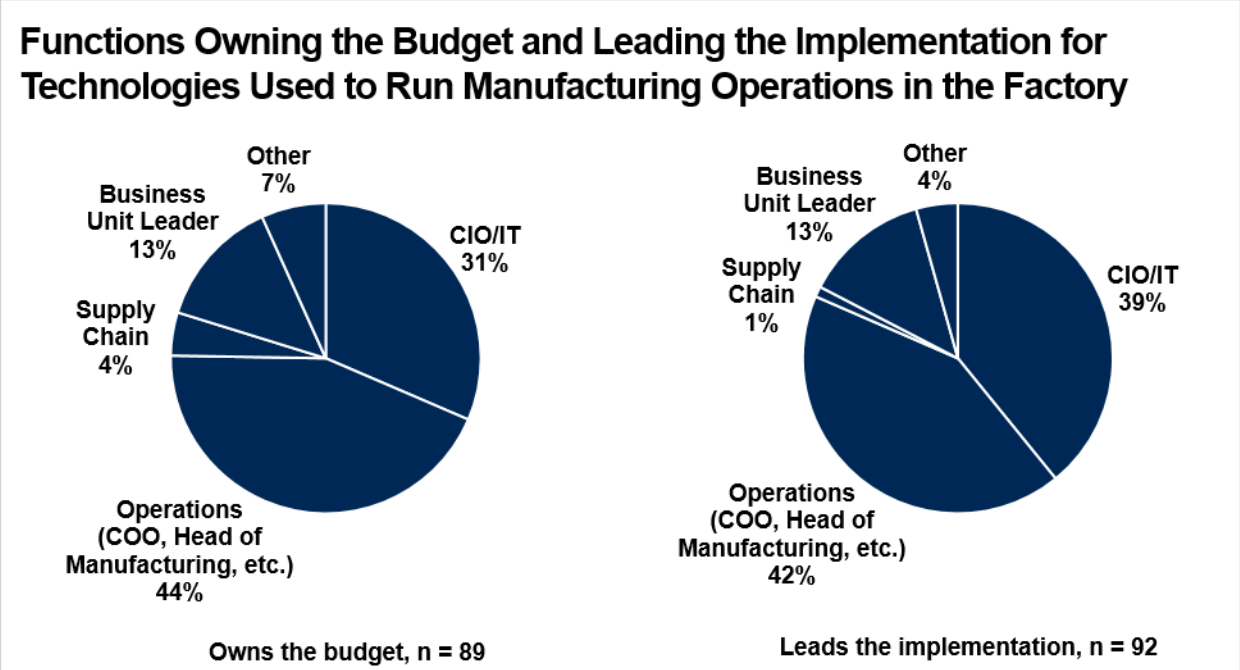
Actions

Manufacturing operations leaders responsible for operations strategy and performance, seeking to maximize the opportunities that smart factories offer, must:

- **Prioritize the convergence and alignment of IT and OT.** Several companies are focused on creating smart factories by augmenting OT with IIoT. It is being done through analytics, virtualization- and/or cloud- and sensor-based technologies. This convergence and integration of IT and OT is much further along than the alignment. Alignment is the process of synchronizing standards, supporting processes, security and architecture plans to build in compatibility between the IT and OT systems. IT and OT are inseparable in smart factories. However, in many instances, the responsibilities for OT and IIoT are outside of the domain of the IT department and/or the supply chain. This is a big opportunity for knowledge transfer and acute attention to the collaboration points between both worlds (security, integration). Identification of talent gaps should be prioritized with a focus on alignment, not duplication. This can be accomplished by steering responsibility and scale, not ownership and accountability. Realize now that any desired success with managing assets, assimilating to cloud computing and improving the overall long-term reliability of manufacturing operations means bringing these domains together through new organizational models and technology roadmaps.
- **Prepare for the big cultural changes that smart factories will create globally and locally.** The “not invented here” culture is slowly fading in factories. Frontline employees are more engaged than they were previously. New technologies and digital experiences will need new skills. More broadly, and importantly, on a global scale, expect sizable impacts in other domains of the business. Aligning new factory models with different supply chain designs and new digital business operating models could lead manufacturing operations leaders to emphasize different metrics (or take on new ones altogether). (See “Use the Hierarchy of Manufacturing Metrics to Connect Manufacturing and Supply Chain Performance.”) Manufacturing operations leaders

must also be prepared to shift their relationship with the CIO and his or her team. Both groups are striving to innovate production, but as shown in Figure 3 from Gartner's 2018 Business Value of MES Survey, each plays sizable roles in manufacturing technology acquisition and deployment. In some instances, the CIO's office has led the development of smart factories. (See "POSCO Launches a Digital Smart Factory Initiative to Gain a Competitive Edge.")

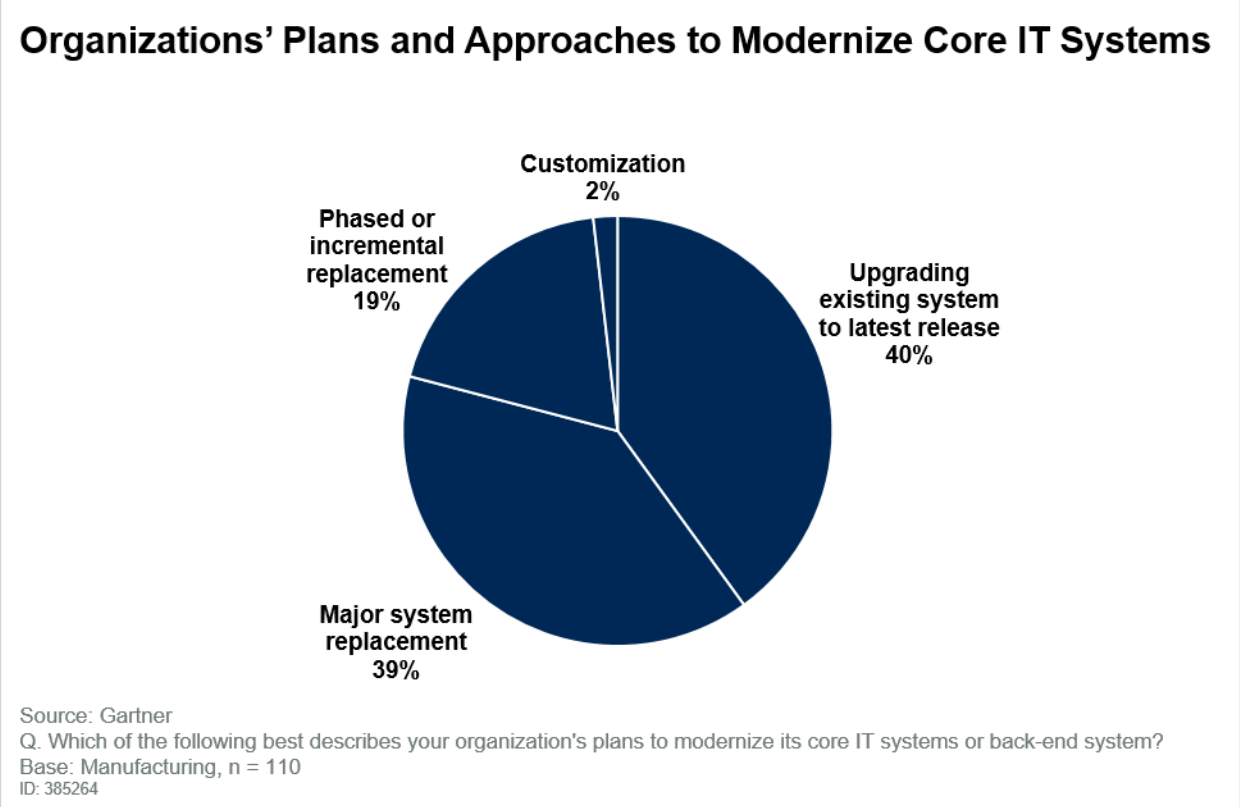
Figure 3. Functions Owning the Budget and Leading the Implementations of Technologies Used in Manufacturing Operations



- **Embrace the role that emergent standards and reference models** can offer an organization through a baseline for common lexicon for consistent engagement across different functions and geographies. There is no shortage of options to choose from spanning those from Reference Architectural Model Industrie (RAMI) 4.0, Platform 4.0, Clean Energy Smart Manufacturing Innovation Institute (CESMII) and National Institute of Standards and Technology (NIST). There are also more tactical integration standards such as OPC and MQTT. At the most basic level, reference models and standards will help with business case, technical feasibility and value proposition evaluations. At a more detailed level, some might lend process maps and templates that help identify assets, applications and data — as well as potential resource allocations and security requirements. All of which are helpful for scale should prototypes be proven. However, standards still point toward individual processes and use cases versus a complete smart factory concept.

- **Appreciate that smart factories are more than greenfield opportunities.** Greenfield might be blue sky opportunities but brownfield, existing facilities offer significant potential — and are where today's value is created, and flexibility must be retained. However significant repair to existing systems is needed. Manufacturing operations doesn't upgrade its systems at the pace of the rest of the enterprise and many facilities still have platoons of homegrown applications; all of which create constraints. In many instances, core systems like manufacturing execution systems (MES) require attention for broader smart factory objectives to be met. Only 29% of the manufacturers that participated in a 2018 Gartner survey on legacy system modernization report that they have completed their modernization efforts in the past 24 months. Figure 4 shows that there is no dominant approach to modernizing legacy systems. This means organizations need to develop implementation and upgrade plans that mesh existing and new capabilities, required to meet business goals, to help bridge any potential technology and business process gaps. (See "Digital Manufacturing Requires a New Look at Old Systems.")

Figure 4. Organizations' Plans and Approaches to Modernize Their Core IT Systems



- **Use bimodal to unleash the innovation potential of smart factories.** Bimodal is the concept of having two distinct but coherent approaches to creating and delivering business change through two modes of operations. Each mode is designed to develop and deliver quality, customer value (growth) and perfect orders (revenue) in their own way. Mode 1 optimizes what is known, while Mode 2 is more revolutionary, fluid and adaptive. Use a strict but a rapid

process of leveraging discretionary budget to fund Mode 2 projects that are not dependent on traditional business cases and customary ROI approvals. Also, avoiding a narrow focus on one technology by establishing a stable test-and-learn is critical. The objective is to ultimately identify which technologies (or combinations thereof) will have ubiquitous potential. Be prepared to augment traditional lean thinking that focuses on optimizing what is known with a more exploratory "exploit the unknown" mindset. In parallel be aware that bimodal does not offer a way to avoid tackling the thorny issues of renovating the cultural and structural core of manufacturing operations. Nor is it an excuse to extend or breathe life into outdated or ineffective behaviors and processes. Instead, bimodal requires developing operational discipline to achieve synchronization between the two modes. It starts with changing the discussion on risk and ROI by jointly developing risk-and-reward models with factory and functional leaders that favor embracing uncertainty. (See "How to Overcome Three Obstacles to Accelerate Innovation in Manufacturing Operations With Bimodal.")

- **Avoid an inside-out focus.** It is unrealistic to expect increased margin contribution and improved competitiveness when smart factories and the manufacturing-excellence initiatives they support are confined within a single site or focused on an individual subfunction (e.g., quality, maintenance and production planning). To meet the top-down objectives for improving supply chain performance, the performance improvements and development of new capabilities from the bottom up must contribute to systemic improvements across the supply chain. Improvements in site-level cost, quality, reliability and process capabilities are achievable with most any infusion of technology into factories. As more companies deploy different technologies in factories, it is essential to align the derived benefits with a broader, future-facing roadmap. This ensures alignment with customer-facing outcomes, end-to-end supply chain processes and metrics, and organizational designs. As part of its endeavor to have larger and more efficient factories P&G is ramping up a smart factory in Martinsburg, West Virginia (expected to be fully operational by 2020). P&G has consolidated the production of 11 major brands into this site. It will use an extensive combination of robotics and automation to support (what it refers to as) "touchless processes" that are synchronized with its supply chain to shorten order fill rates. It also intends to employ just under 2,000 workers at the site.[4]

Gartner Recommended Reading

Some documents may not be available as part of your current Gartner subscription.

"Hype Cycle for IT Evolution in Manufacturing, 2018"

"Hype Cycle for Manufacturing Operations Strategy, 2018"

"Harvest the Value of Smart Manufacturing in the Supply Chain, Not the Factory"

"The Importance of OT Integration for Industrie 4.0"

"Manufacturing Industry Scenarios in 2023: Leading Through Innovation"

Methodology

Manufacturing Top 10 Technology Trends were established by analysts covering this segment. Selection was based on client interactions, proprietary research, Gartner surveys, and in conjunction with original Top 10 Technology Trends author, David Cearley.

Figure 3: Gartner's MESA Business Value of MES Survey, 2018: Results are based on a Gartner study conducted from 11 October 2018 through 11 January 2019 with Gartner contacts and members/contacts of MESA International (Manufacturing Enterprise Solutions Association). This was the seventh year the study has been fielded with this association. Ninety two respondents from MES-user companies participated. Participants were screened to be in manufacturing industries, have an MES system and to have a role in decisions related to MES. The purpose of the study was to assess if, and to what extent, MES applications are delivering ROI and creating value for companies in the manufacturing industry, and specifically to identify the characteristics of organizations maximizing the value and returns on their MES investments. The survey was developed collaboratively by a team of Gartner analysts who follow supply chain and was reviewed, tested and administered by Gartner's Research Data and Analytics team.

Figure 4: Results presented are based on a Gartner Legacy Modernization study to understand the stage of legacy modernization, what strategies organizations are pursuing and how legacy modernization will help to drive transformation. The primary research was conducted online during August through October 2018, among 659 respondents in organizations with more than $250 million in annual revenue. Respondents were screened for involvement in their organization's core IT systems modernization activities. Results presented are based on respondents from manufacturing (n = 110).

Evidence

[1] "HP Unveils S$100M Campus, Home to Its First Advanced Manufacturing Centre," The Business Times.

[2] "ABB Opens Smart Factory for Electrical Safety, Energy Efficiency Products in Bangalore," Zee Business.

[3] "GM Prefers Smart Manufacturing to Industry 4.0," WardsAuto.

[4] "P&G Promises Mega 'Factory of the Future' as It Shuts Down Old Sites," Cincinnati.com, USA Today Network.

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