Lights-Out Production Will Be a Reality by 2025

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Initiatives: Manufacturing Operations

Advancements in technology will make lights-out production processes a reality in 2025. Supply chain leaders responsible for manufacturing operations must avoid an inside-out approach, be prepared for process trade-offs and overcome more than just technical burdens.

Overview

Impacts

- Increased ambitions of lights-out production processes elevate factory automation to a supply chain strategy.
- Operating smart factories requires balancing augmented and automated processes.
- Achieving lights-out production capabilities requires eliminating more than just technical burdens.

Recommendations

Supply chain leaders responsible for manufacturing operations strategy and performance must:

- Strive to create a scenario where margin gains outweigh conversion costs by factoring service, product life cycles, risk and competitive positioning, and shoring analysis into your automation business case and decisions.
- Avoid a reflexive approach to automation by leveraging a cost-benefit analysis that quantifies the benefit of augmented and automated processes against the total value potential to the business or the customer experience.
- Realize long-term cost benefits by taking a disciplined approach that eliminates current technical burden by balancing technology and labor costs — not just capitalization on quick wins and enhancing operational excellence.

Strategic Planning Assumption

By 2025, 60% of manufacturers will have more than two completely lights-out processes in at least one of their facilities.
Analysis

Attitudes and ambition for lights-out production are changing. Participants in the 2020 Gartner Manufacturing Strategy and Implementation Trends Survey anticipate a 21% increase in lights-out production processes in the next five years. 1

Lights-out production processes are completely digitized processes that operate with minimal to zero human intervention

This bullishness for lights-out production processes is illustrated in Figure 1. It reflects the shift toward hyperautomation — the application of advanced technologies such as artificial intelligence (AI) and machine learning (ML) to increasingly automate processes and augment humans. It also reflects the growth of autonomous things — physical things that are enhanced with greater capabilities through AI and Industrial Internet of Things (IIoT) to perceive, interact, move and manipulate different factory environments with various levels of human guidance, autonomy and collaboration.

Both of these technology trends expose the opportunity to transform factory automation from capital-intensive, form-factor-based concepts within factories to create new, virtual production processes and boost competitiveness, cost efficiency and agility through reliable supply from factories.

Figure 1: Ambitious Expectations for Lights-Out Production in 2025

Ambitious Expectations for Lights-Out Production in 2025

<table>
<thead>
<tr>
<th>Majority of Manufacturing Operations</th>
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<tbody>
<tr>
<td>Today (n = 439)</td>
</tr>
<tr>
<td>15% (Completely digital, lights-out processes)</td>
</tr>
<tr>
<td>70% (Human-driven, manual processes augmented with digital)</td>
</tr>
<tr>
<td>15% (Human-driven, manual processes only)</td>
</tr>
<tr>
<td>5 years from now (n = 439)</td>
</tr>
<tr>
<td>36% (Completely digital, lights-out processes)</td>
</tr>
<tr>
<td>45% (Human-driven, manual processes augmented with digital)</td>
</tr>
<tr>
<td>3% (Human-driven, manual processes only)</td>
</tr>
</tbody>
</table>

Base: Excludes “Don’t know” responses
Q. What best describes the majority of your manufacturing operations today?
Q. And thinking about five years from now, what do you anticipate your manufacturing operations will look like?
Source: 2020 Gartner Smart Manufacturing Strategy and Implementation Trends Survey
ID: 725171
The combination of digital ambitions of the supply chain organization and the manufacturing function, and COVID-19’s influence on how factories are managed, with advancements in technology that converge the virtual and physical worlds to improve how data is accessed, processes are managed and decisions are made created a perfect storm for lights-out production.

Conversely there are a series of inhibiting factors, including access to skills and capital, changes to culture and processes, securely managing and converging the physical and virtual worlds of the smart factory (or broader cyber-physical systems [CPS]), and convergence with other supply chain functions (see Glossary Terms for further information).

This research assesses the key impacts and provides recommendations for supply chain leaders responsible for manufacturing operations strategy to chart their path toward a lights-out future (see Figure 2).

**Figure 2: Impact and Top Recommendations for Supply Chain and Manufacturing Operations Leaders**

<table>
<thead>
<tr>
<th>Impacts</th>
<th>Top Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing ambitions for lights-out production elevate factory automation to a supply chain strategy.</td>
<td>• Strive to create a scenario where margin gains outweigh conversion costs by factoring service, product life cycles, risk and competitive positioning, and shoring analysis into your automation business case and decisions.</td>
</tr>
</tbody>
</table>
| Operating smart factories requires balancing augmented and automated processes. | • Prepare to do a rigorous processes assessment that incorporates simulation and value stream analysis to break down the cost benefit of fully automating a process or not. This analysis can shed light on how technology adjustments change a process or behavior — and whether a complete redesign of adjacent processes or standard work itself is needed.  
• Avoid wasting time and money or inadvertently creating volatility by acutely differentiating the blend of automated and augmented processes with an understanding of the impact that technology will have on the entire operation and not a project-specific basis. This avoids an extreme and reflexive assumption that places automation as a means to an end or homing in on narrow benefits. |
| Achieving lights-out production capabilities requires eliminating more than just technical burdens. | • Develop an iterative and phased investment strategy that accounts for technology and labor costs. This strategy includes initial costs, upgrades and system maintenance, upskilling, and flexibility against changing requirements.  
• Realize long-term cost benefits by taking a disciplined approach that eliminates current technical burden by balancing technology and labor costs — not just capitalization on quick wins and enhancing operational excellence. |

Source: Gartner (February 2021) ID: 725171

### Impacts and Recommendations

**Increased Ambitions for Lights-Out Production Elevates Factory Automation to a Supply Chain Strategy**
Using autonomous mobile robots (AMRs) or cobots to manage routine and nonroutine tasks; or AI and IIoT to reduce unplanned events by continually monitoring, analyzing, and improving various production processes, exemplify that lights-out production is technologically possible today and will increase over the next five years. As technological sophistication grows and the cost of entry goes down, the execution of routine and nonroutine tasks will be increasingly handed over to algorithms and robots.

Investments in automation and how it is leveraged varies by production model, site requirements and by company strategy. For some companies, this means pushing forward with site-specific and inside-out approaches that leverage automation to emphasize safety, cost efficiencies (e.g., direct labor, materials conversion, and overhead), and hedge against operational risk (as part of a business continuity management [BCM] strategy). In some instances, COVID-19 amplified this approach — manufacturers looking to automation as part of a nearshoring strategy that makes production economically viable in high-cost markets (see The Route to a More Resilient Supply Chain). Other organizations will take a more progressive approach and look at increasing factory automation through a strategic lens. This is a more holistic approach to automation as it emphasizes diffusing benefits beyond the factory to support new business models (e.g., strategies centered on e-commerce and/or product customization).

Moving toward lights-out capabilities reflects the ongoing shifts in process innovation and technology strategies but doesn't imply that organizations are always aligned. Although four out of five survey respondents agree that their leaderships understand and accept the need to invest in smart manufacturing — matching expectations for manufacturing operations to generate growth and revenue from PowerPoint to practice won't be easy.

Ensuring that the enterprise’s vision doesn’t supersede its existing capabilities requires investment in convergence and synchronization with other supply chain functions. For example, one tire manufacturer developed technology to automate critical assembly processes and improve yield by combining IIoT and deep learning. This technology also increased output, requiring an investment in warehouse capacity.

Recommendations:

- Prepare your move to lights-out production by developing a business case that connects lights-out capabilities with the overall health of the business and not just on-site-specific operational excellence gains. This network-based approach minimizes the break points (such as cost or labor constraints) between manufacturing operations and the end-to-end supply chain versus simply cost-reduction focuses.

- Strive to create a scenario where margin gains outweigh conversion costs by factoring service, product life cycles, risk and competitive positioning, and shoring analysis into your automation business case and decisions.

Operating Smart Factories Requires Balancing Augmented and Automated Processes

Figure 3 shows how survey respondents describe their manufacturing operations today and how they expect them to be managed in the future. The ambitions toward automated, lights-out processes, carries
over from Figure 1 and aligns with the ongoing interest in smart factories. It also amplifies the interest in completely lights-out, autonomous factories.

**Figure 3: Expected Shifts in Automation by Process Today and in 2025**

Expected Shifts in Automation by Process Today and in 2025

<table>
<thead>
<tr>
<th>State of Manufacturing Processes and/or Activities</th>
<th>Production scheduling (n = 433)</th>
<th>Quality management (n = 435)</th>
<th>Reporting/KPI management (n = 433)</th>
<th>Materials handling and/or logistics (n = 430)</th>
<th>Changeovers (n = 428)</th>
<th>Lean and continuous improvement (n = 431)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Today</strong></td>
<td><strong>Next 5 yrs</strong></td>
<td><strong>Today</strong></td>
<td><strong>Next 5 yrs</strong></td>
<td><strong>Today</strong></td>
<td><strong>Next 5 yrs</strong></td>
<td><strong>Today</strong></td>
</tr>
<tr>
<td>39%</td>
<td>64%</td>
<td>30%</td>
<td>59%</td>
<td>35%</td>
<td>45%</td>
<td>28%</td>
</tr>
<tr>
<td>36%</td>
<td>24%</td>
<td>43%</td>
<td>30%</td>
<td>45%</td>
<td>24%</td>
<td>46%</td>
</tr>
<tr>
<td>25%</td>
<td>11%</td>
<td>27%</td>
<td>11%</td>
<td>20%</td>
<td>12%</td>
<td>28%</td>
</tr>
</tbody>
</table>

Manufacturers: Excludes “Don't know” and “NA” responses
Q. What is the current state of each manufacturing process/activity below?
Q. Now please tell us what you anticipate the state of each manufacturing process/activity to be five years from now?
Source: 2020 Gartner Smart Manufacturing Strategy and Implementation Trends Survey
ID: 725171

Respondents agreeing that smart manufacturing boosts competitiveness expect at minimum 10% or greater growth in lights-out processes in the next five years. Additionally, respondents that agree manufacturing operations are a critical part of their digital supply chain strategies are likely to expect the same increases for materials handling, quality management and reporting. This means both horizontal and vertical integrations (see Glossary Terms for further information) will be required to converge different functions and processes, creating a network view and feedback loop that enables manufacturing to be optimized as part of a broader cyber-physical system across the supply chain.

However, not all processes will evolve in the same fashion. Although it's no surprise that the manual processes — either human-driven, or those in isolated and legacy transactional systems — will decrease over the next five years, digitizing or innovating simple or manual task orientation to a more sophisticated, online process isn't black and white. In some instances, it's highly unlikely that methods and procedures for continuous improvement will be fully automated. This reflects ambition and also confirms the reality of transitioning from manual practices to augmented ones to enhance Gemba walks or shift handoffs. In other cases, tightly coupled processes lack the flexibility for easy change. Different combinations of augmented and automated processes will be driven by production models, technological sophistication and site objectives. Tables 1 and 2 provide the differentiation and benefits between the two approaches to managing production activities.
Table 1: Augmented Processes and Activities in Manufacturing Operations

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<table>
<thead>
<tr>
<th>Process Type</th>
<th>Differentiation and Consideration</th>
<th>Examples</th>
</tr>
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</table>
| Augmented processes are human-driven, manual processes that are augmented with digital. | Also referred to as “human-in-the-loop automation” this approach offers the best of both worlds. This is done by amplifying worker capabilities by combining standard work, IIoT, and either advanced analytics or a form of AI to ensure a specific activity or set of procedures are executed without variance (e.g., materials preparation and/or kitting, inspections, or maintenance). The engagement and involvement of the worker is essential. | ▪ Using immersive experiences to guide the execution of a specific task. May also include incorporation of robotic process automation (RPA) and natural language processing (NLP) task management to accelerate decision making.  
▪ Augmenting transactional systems with vision systems and algorithms. This accelerates continuous improvement, worker efficiency and upskilling by identifying opportunities to lessen ergonomic strain or execution times. |
Table 2: Automated Processes and Activities in Manufacturing Operations

<table>
<thead>
<tr>
<th>Process Type</th>
<th>Differentiation and Consideration</th>
<th>Examples</th>
</tr>
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</table>
| Automated processes are completely digitized, lights-out processes. | These straddle the physical and digital form factors to operate autonomously. Processes operate with an increased level of sophistication as technology absorbs complexity through improved data access and algorithms (e.g., condition monitoring, image analysis). However, this requires constant training and self-learning. | - Shortening inspection time by combining computer vision and edge technologies for high-volume production.  
- Improving new product scale-up using RPA to convert engineering bill of materials (eBOM) to manufacturing bill of materials (mBOM).  
- Lessening downtime costs, overhead and order backlog by using autonomous things to replenish workstations, load materials, or manage changeovers. |

Source: Gartner (February 2021)

These two approaches are not mutually exclusive and will compel manufacturers to find the right blend. In the production of consumer products it may look like this: operators use augmented reality (AR) and RFID scanners in the preweigh and processing of raw materials to ensure the right quantities are kitted for each order. In primary processes there are a series of algorithms that monitor processing parameters and automate error identification, increasing batch accuracy and decreasing loss. For secondary processing, computer vision is applied to manage label placement, requiring consistent updating as product variants continue to expand.

The path might not be as straightforward but what is clear is significant change. Not only must concerns for job loss be managed, attention needs to be given to educating leadership on where the blind spots are — and not just the benefits. An equipment manufacturer might focus on new equipment or automating setup times as a means to increase capacity or capability to produce components without additional cost or quality consequences. Collateral benefits might be reductions in work in process (WIP) and/or labor content. The underlying change management can be significantly underestimated. Standard work and assembly processes might change; and kitting, part sorting, routing and materials logistics processes might require reengineering too. This underscores the need for collaboration and potential upskilling across stakeholders from manufacturing, IT, engineering and/or operational technologies (OT), and supply chain domains.
Recommendations:

- Prepare to do a rigorous processes assessment that incorporates simulation and value stream analysis to break down the cost benefit of fully automating a process or not. This analysis can shed light on how technology adjustments change a process or behavior — and whether a complete redesign of adjacent processes or standard work itself is needed.

- Leverage that cost-benefit analysis by quantifying the benefit of augmented and automated processes against the total value potential to the business or the customer experience. In some instances, it might be beneficial to carry a higher manufacturing cost as the savings can be identified elsewhere in the supply chain.

- Avoid wasting time and money or inadvertently creating volatility by acutely differentiating the blend of automated and augmented processes with an understanding of the impact that technology will have on the entire operation and not just on a project-specific basis. This avoids an extreme and reflexive assumption that places automation as a means to an end or homing in on narrow benefits.

Achieving Lights-Out Production Capabilities Requires Eliminating More Than Just Technical Burdens

Seventy-nine percent of asset intensive organizations’ desire to apply Internet of Things (IoT), and augment existing OT monitoring and control systems, highlights the need for newer, modern production capabilities (see Survey Analysis: U.S. Enterprises See IoT Adoption as a Path to Augment and Replace OT Functions).

Lights-outs production will be an inevitable reality by 2025, but at what expense?

While the cost of some technologies (for example, robots) have decreased and the ROI on automation can be gifts that keeps on giving, it is also economically unrealistic to expect a complete rip-and-replace of existing investments to achieve lights-out capabilities. Accessing the capital budgets to fund smart manufacturing initiatives is a challenge. Of the CFOs that were surveyed, 68% agree that accessing the capital budgets to fund initiatives is a struggle, which is significantly higher than 53% of all respondents.

Compounding the challenge is technical debt. Technical debt is the deviation of a system from any of its nonfunctional requirements. The legacies of homegrown and nonstandard applications in factories have contributed to the gradual accumulation of technical debt. For example, maintaining or upgrading OT in the form of programmable logic controllers (PLCs), flow meters, electro-mechanical conveyors and other equipment — or the hodgepodge patchwork of information technologies in factories — is part of an extensive and expensive set of processes and projects that drive factories further into debt. In some instances, upgrading the OT alone has cost some discrete manufacturers between $130,000 to $380,000 per work cell. Stakeholder-centric incentives for managing technical debt are needed and this will require the alignment of engineering technologies (ET), IT, OT and other plant-level stakeholders with the supply
chain strategy, without oversight of costs for security, integration and process reengineering. Taking this broader approach aligns incentives and projects.

It is more than just technical debt that needs to be overcome. There's a larger collective organizational debt (technical, process, data, architecture and social — see Glossary Terms for further information) that significantly impacts the value proposition of lights-out production. Automation is the commodity and despite programs that aggressively seek to replace factory workers with robots or provide incentives for automation — labor isn't a commodity. This blurs the lines between technology and labor costs. Labor will be for the interim — atop the cost trade-off list for lights-out production considerations. The problem is that in the short and/or midterm labor costs will increase, as specialist skills are needed in order to implement technologies that either automate or augment production processes. The technological sophistication of automation — curating deep learning models, programming robots, or understanding of sophisticated control logic, and piping and information displays (P&ID) — are all specialist skill sets that place existing human skills and knowledge at a premium. These new skill sets cost more than the hourly rate structures that many factories have long operated on — presenting potential risk of increasing labor costs before they’re lowered. Furthermore, short-term strategies for workforce resilience only run the risk of inadvertently creating more talent debt. Specifically, eliminating the busy work for an engineer with RPA might reduce non-value-adding activities and “improve the worker experience.” However, this can also, inadvertently, create tomorrow’s overhead reduction target. Additionally, managing increased levels of automation demands new skill sets that not all organizations have.

Recommendations:

- Develop an iterative and phased investment strategy that accounts for technology and labor costs. This strategy includes initial costs, upgrades and system maintenance, upskilling, and flexibility against changing requirements.

- Understanding quick wins and enhancing operational excellence might buy credibility, however the longer-term cost benefits will be realized as part of a disciplined approach that balances technology and labor total cost of ownership (TCO) against technical debt to eliminate.

Glossary Terms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Smart Factory</td>
<td>Smart factory is a concept used to describe the application of different combinations of modern technologies to create a hyperflexible, self-adapting and continually optimized production capability. It is an underlying capability of smart manufacturing, which, in turn, fuels digital supply chain and Industrie 4.0 initiatives (see Hype Cycle for Manufacturing Operations Strategy, 2020).</td>
</tr>
<tr>
<td>Horizontal and Vertical Integration</td>
<td>Horizontal Integration: Horizontal integration focuses on extending and connecting control systems from production with other functions or process steps that are being executed in the value chain. Although this CPS will be harder to achieve, it is necessary as increases in both process automation and</td>
</tr>
</tbody>
</table>
production localization need higher levels of flexibility and synchronization beyond “just manufacturing the product.”

| Vertical Integration: The vertical integration of systems and processes goes beyond the “shop floor to top floor” integration scenarios that narrowly report inventory consumption, order quantities and some quality data. Traceability and real-time production data are still important; however, a wider range of processes is in focus. A semiconductor manufacturer's vertical integration focuses across global planning, master planning, factory scheduling and machine scheduling, with a feedback loop from its manufacturing processes to understand performance. This helps it continually refine where it needs to automate or improve processes, as well as where more flexibility can be achieved. |

| Collective Organizational Debt | Collective organizational debt is made up of many elements that are often hard to quantify. Debt categories include technical debt, process debt, data debt, architecture debt, talent debt, security debt and social debt. The value of discussing debt isn’t in trying to precisely quantify it. Rather, the value is in helping raise awareness of important concepts among stakeholders (see Top Strategic Technology Trends for 2021: Hyperautomation). |

| Technical debt is the most well-known form of debt. It enables IT leaders to express a combination of factors. IT leaders use it as a proxy to articulate and discuss limitations that prevent IT teams from saying "yes" to the business because of complexity, increased cost and/or investment, and speed. Technical debt is rarely expressed as a quantitative number. It’s expressed as the main reason why IT teams struggle to implement quickly. |

| As business executives continue to strive for digital operational excellence, and the demand for speed and efficacy continues, it is necessary to look beyond IT. It is important to look at the collective debt from not only technology, but also process, data, architecture, talent, security and social and/or community demands. We summarize these terms as follows: |

| Process debt — Suboptimal activity or process that might have some benefits, but generates a sustained negative impact on cycle time, error rates, quality, consistency, complexity or customer experience. |

| Data debt — Lack of or suboptimal access to current or accurate data within the demand latency period. |

| Architecture debt — Suboptimal solutions from an optimized architectural construct. This may lead to security issues, latency and redundancy (in applications, infrastructure, instances, APIs, licensing or subscription costs). |

| Talent debt — Lack of talent (human workers, augmented humans or virtual workers) in either the quantity, quality, or ability to scale to fuel optimization or growth. |

| Security debt — Inability to proactively or reactively address a broad set of security risks or breaches. Security debt ranges over a broad spectrum from physical security to cybersecurity, and many areas in between. |
Social debt — Suboptimal activity or a sustained negative impact on the organization's ability to address social, societal and community issues. For example, if an organization wants to address climate change issues, but lacks the agility because of its culture, diversity, talent or other factors, then it has high social debt.

Recommended by the Author

The Path to the Lights-Off Supply Chain: The Rise of AI to Automate Supply Chains of the Future

Prepare to Reskill Your Supply Chain Workforce in the Age of Hyperautomation

From Human Augmentation to Lights-Out Production: How Far to Go With Industrial Automation?

Hype Cycle for Manufacturing Operations Strategy, 2020

The 2020 Top Strategic Technology Trends for Manufacturing Operations

Understand the Need for Supply Chain Execution and Manufacturing Operations Management Convergence

The Importance of OT Integration for Industrie 4.0