A BUSINESS IMPERATIVE IN MANUFACTURING

Strategic implementation of **crane automation**

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Abstract
Cranes are crucial to industrial infrastructure, handling heavy lifting across yards and shopfloors. However, their role goes far beyond just lifting—they are precision machines critical to material flow, operational efficiency, and workplace safety. With load identification, anti-sway technology, energy savings, remote operation, and advanced safety features that leverage data and AI, automation offers a transformative edge. Automated cranes operate with intelligence and adaptability, allowing them to outperform manual systems in terms of precision, efficiency, and availability.

This paper demonstrates how industrial cranes can benefit from advanced automation, highlighting requirements for next-generation cranes and offering an approach toward implementing advanced crane automation.

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Contents

Automating crane operations for competitive advantage

In spite of the evolving demands of crane operations, many industry professionals continue to rely on traditional, manually operated crane systems. The assumption is that the operational expenditure on these tried-and-true methods is less costly than the capital expense of an upgrade. However, conventional crane operations are in fact riskier, costlier, and less competitive than automation, for several reasons: They are prone to (human) error, require skilled workers, offer only limited options for improving operations based on data, and may present undesirable work conditions. These factors contribute to substantial operational expenditure. In contrast, although state-of-the-art automation and data-based operation solutions incur higher capital expenditures, they ultimately help lower operational costs, yielding a lower total cost of ownership.

In addition, companies are faced with the challenge of attracting new talent to their workforce. Younger professionals have grown up in an increasingly automated world and are more accustomed to using technology-driven solutions. This experience is often in stark contrast to the work environment in manually operated cranes, where conditions include dust, heat, and noise—potentially not only making the job unattractive but also posing health and safety risks. The good news is that crane automation has come a long way, offering a wealth of opportunities to enhance safety, improve efficiency, and drive down costs.

Proven technologies applied to crane automation

Numerous examples from all areas of industry have proven how automation contributes to safer and more productive crane operation. The following stories demonstrate that crane automation is no longer experimental but a proven strategy for operational excellence.

- **In the automotive industry: Optimizing space requirements and engineering efficiency**

Faced with space constraints in an automotive assembly plant, a crane OEM in Europe deployed compact, highly automated process cranes integrated with anti-sway technology, distance monitoring, and condition-based diagnostics. The result was a 20% reduction in engineering time and improved safety margins—achieved through precision control, minimal manual intervention, and seamless system integration.
Learn more

- **In the paper industry: Driving productivity through remote operations**

A leading paper manufacturer in Brazil successfully transitioned to remote-controlled crane operations, resulting in a significant boost in productivity. This improvement was driven by uninterrupted shift operations, enhanced visibility into crane activities, and reduced equipment downtime—all achieved with fewer human operators.
Learn more

- **In the steel industry: Reducing downtimes through fast troubleshooting and fault diagnostics**

In a high-temperature, dust-heavy steel plant in India, the manufacturer implemented a centralized crane management system to monitor cranes from multiple automation suppliers. The system was designed to ensure seamless integration, allowing for flexibility and interoperability across the plant. This setup enabled improved resource allocation, increased crane availability, and real-time fault diagnostics. For example, the new system detects critical vibration anomalies early, allowing for prompt corrective actions that help prevent equipment failures.

Studies show that almost 40% of crane-related accidents on the shopfloor happen due to load sway, which can be easily avoided using automated anti-sway controls. Today some of the coil yard and slab yard facilities that use advanced automation have integration between their crane systems and their warehouse management systems (WMSs). Such integration enables real-time tracking, optimized stacking, and predictive scheduling. Through vertical and horizontal process integration, facilities demonstrate reduced turnaround times and maximized storage efficiency. Nighttime autonomous operation prepares materials for early-morning dispatch—without expensive human supervision.

Solutions such as sway control and warehouse management are not new; they are based on technologies that have been widely applied in many industries and organizations. The examples above, and numerous others from all areas of industry, have proven how automation contributes to safer and more productive crane operation.

Obstacles to adopting crane automation

Companies that embrace such innovations are not only improving their bottom line. They are also future-proofing their operations against workforce shifts, regulatory demands, and increasingly complex industrial logistics. So why aren't state-of-the-art automation solutions applied more widely to industrial cranes? Some reasons may be found in the specific requirements and settings of industrial crane operation.

- **Complex operational environments**
  Industrial cranes often operate in complex environments, such as manufacturing plants, chemical facilities, or production lines. These locations may have unpredictable conditions and obstacles. Designing an automation system that is safe and can adapt to such dynamic environments and diverse tasks is a challenge.

- **Waiting for proven success rather than taking a lead**
  Even companies that recognize the potential of automation may still hesitate to adopt these technologies in their crane operations due to concerns about the maturity and reliability of the existing solutions. Some adopt a wait-and-see approach, holding off until there is a proven track record of crane automation in *their specific* industry or application, instead of looking to benefit from the experience of *similar* industries.

Though avoiding unnecessary risks is a legitimate business strategy, an overly conservative approach will lead to stalled innovation, which ultimately aggravates the underlying issues.

- **A workforce "Catch-22" situation: Upskilling versus attracting new talent**
  The industrial sector faces a critical workforce dilemma. To successfully transition toward automation, it is essential to upskill experienced workers. Yet a significant portion of the current workforce is approaching retirement within the next 7–10 years, so employers must also begin to recruit and onboard these employees' eventual replacements. To complicate matters, younger people often perceive the industrial sector as harsh, outdated, and less appealing than modern, tech-driven fields. Companies are caught in the middle. They must modernize to attract new talent while relying on the existing workforce to drive that very modernization. Balancing the requirements for upskilling employees with the need to attract new talent can be a significant challenge.

- **Infrastructure readiness**
  Many facilities still operate with legacy infrastructure that lacks the backbone required for automation. Retrofitting these environments demands significant investment, planning, and operational downtime. Without foundational upgrades in connectivity, data integration, and control systems, the benefits of automation remain largely theoretical. While greenfield sites may allow for seamless automation integration, brownfield facilities require careful adaptation of existing infrastructure to bridge the gap between legacy and smart systems. The following section takes up infrastructure considerations in more detail.

Preparing for the next generation of automated cranes

Infrastructure readiness for crane automation

One of the primary challenges in advancing automation in industrial environments is ensuring infrastructure readiness. The successful implementation of crane automation requires a comprehensive assessment of the existing infrastructure: its legacy control systems, physical layout constraints, data connectivity, and workforce readiness. In addressing these critical factors, a strategic and phased approach is essential for effectively deploying the appropriate level of crane automation. Table 1 depicts the key requirements and design considerations for crane automation systems and the factors influencing the key considerations of connectivity, latency, safety, scalability, and data management.

Requirement	Possibilities	Influencing factors
Connectivity	Assessing the suitability of industrial networks such as WLAN, 5G, or fiber optics is crucial for effective communication.	• Infrastructure including steel structures • Clear line of sight • Local regulations • Investment levels
Latency	Operators require real-time data, with live information available consistently, allowing for informed decision making in critical situations.	• Number of sensors deployed • Operational cycle frequency • Emergency stop protocols • Remote operation requirements (Cameras supporting ONVIF protocol0
Safety	Comprehensive risk analysis, Strategic placement of Cameras and sensors must be sufficient to ensure operational visibility to eliminate blind spots. Safety circuits must react immediately if a signal is lost. Systems should incorporate people and object detection capabilities, with clearly marked zones for manual intervention.	• Frequency of human touch points • An optimal yet safe environment • Balance between ease of maintenance and reliability, with the goal to prevent frequent failures
Openness and scalability	Both systems and subsystems must utilize standardized and open protocols to facilitate seamless integration across various platforms.	• RFQs from different departments • A long-term strategic vision based decisions considering future equipment and automation level, rather than immediate pricing considerations
Data management and data security	It is crucial to ensure that the right data reach the appropriate user. This encompasses operational, maintenance, and supervisory data, along with data integration from field devices to WMSs.	• Validating the credibility of the source of truth (the WMS) • Adhering to country-specific regulations concerning cybersecurity

Table 1 Infrastructure requirements for crane automation

Degree of delegation: Human versus machine

Nonautomated cranes require manual intervention at various points during the operations they perform. Going forward, depending on the work environment, it will be important to determine which of these interventions should be assigned to automated machines and which should be retained for humans. Standard operating procedures will need to detail all the tasks and checkpoints at both primary and secondary locations—that is, both while the object is on the worksite and after it has left the yard. Therefore, it is essential to identify task flow, parent-child interactions, sensor types and locations, interaction sequences, and cycle times. For example, in an automated coil handling plant, how is the system expected to respond if a coil strap breaks or if a coil shifts by 20 mm or 50 mm? What checkpoints are in place to detect and manage such deviations? Beyond that, how is the correct coil identified and verified? How many sensors are involved, and how is their data sequenced? Finally, does the sensor configuration influence the overall cycle time?

Data for decision making

Relevant information must be accessible locally or remotely—or both—depending on stakeholders' needs. For example, a service technician requires diagnostic data, operators need real-time status notification about the cranes' motions, maintenance managers rely on condition monitoring for efficient scheduling, and plant managers benefit from statistics on overall energy consumption and crane utilization. At the same time, high-quality, real-time, structured data are collected at the yard management level. All of the crane data must be stored and synced with higher-level systems data to help managers make informed decisions and efficiently assign tasks for semiautomated and autonomous crane operations.

Data security and multiuse sensors

Effective automation requires correct and high-quality data. However, equipping cranes with too many sensors—each generating data in a separate cloud environment—makes the system increasingly vulnerable. **A more balanced approach is to use multifunctional sensors.** —For example, a single camera can support AI-based people detection in the yard, provide zoom capabilities for remote crane operation, and serve as a surveillance tool.

Standardization and integration across the lifting ecosystem

Once automation has proven effective at a small scale, companies can begin standardizing and scaling solutions across multiple crane operations. Standardization should begin at the engineering stage and extend through production, ensuring cross-collaboration across all teams and systems. It should also cover the broader lifting equipment ecosystem—including tong selection, WMS configuration, and spare parts management—to support consistent and efficient deployment.

Identifying the right approach to crane automation

Automation does not require an all-or-nothing approach. At one end of the range of possibilities are manually operated systems enhanced with basic automation features. At the other end lie autonomous cranes with XYZ control, capable of making real-time decisions based on changing conditions. Complexity increases with the required degree of automation. A well-designed automation plan should support the chosen approach—now and into the future—through an open, modular, scalable, and standardized architecture.

Standardization as the foundation for crane automation

In today's industrial landscape, crane systems often reflect a patchwork of legacy and modern installations from various OEMs, system integrators, and suppliers. The engineering and commissioning of these cranes frequently depend on the individual skill sets of the personnel involved. This variability leads to inconsistent programming structures, especially in the configuration of advanced functionalities such as grab control (use of the holding/closing gear), synchronized positioning, or load-dependent field weakening.

Regardless of whether a crane is designed for basic, mid-range, or high-performance tasks, the journey toward higher levels of automation begins with the standardization of engineering and commissioning practices. Standardized practices minimize complexity by offering a unified approach to software architecture, control logic, and interface protocols. It also enables faster onboarding and integration of new equipment, especially in plants operating a mix of crane types and generations.

By implementing ready-to-use engineering templates and modular software structures, users can configure or expand crane functionality with minimal effort—often with just a few parameter adjustments or clicks. This ease of use not only reduces engineering and commissioning time but also ensures that the crane system is flexible, paving the way for incremental upgrades on the way toward advanced autonomous operations.

One platform for all crane technologies allows various advanced crane operations to be added, such as sway control.

Mastering operating motions

- **Intelligent sway control**
  Accurate load placement requires more than just operator skill—it demands precise control over any potential crane sway. In manual operations, reducing load sway to just a few centimeters can consume over 30% of the total move time, particularly during long travel or cross-travel motions. This need for precision significantly impacts overall productivity and cycle efficiency. To overcome this challenge, modern crane systems require intelligent sway control solutions that not only dampen oscillations but actively neutralize sway throughout the entire movement. Such systems use a feature called detour control to go beyond basic damping by:

Detour control dynamically adjusting a crane's speed profile for a slowdown region and a blocked region

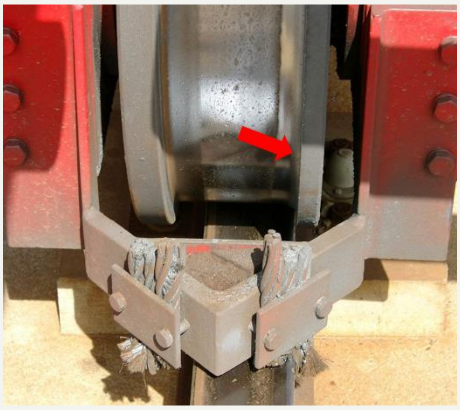
- detecting and compensating for initial sway conditions;
- calculating the shortest, most efficient path to the target—including any necessary detours;
- dynamically adjusting the crane's speed profile by "knowing" precisely when to decelerate and when to stop near obstacles; and
- responding in real time to changes in the path to the target position and recalculating motion trajectories on the fly without reintroducing sway.

System designers should select the most suitable sway control strategy based on the crane's performance class and operating environment. Whether it's for a high-speed overhead process crane or a yard crane exposed to variable outdoor conditions, the correct sway control technology ensures not only smoother operation and greater safety but also measurable gains in cycle time and throughput.

- **Off-tracking management**

  Crane wheels often suffer heavy wear due to frequent flange-to-rail contact. Common causes include unbalanced loads, uneven or dirty rails, nonuniform rail spacing, and speed variations. These factors lead to *off-tracking,* a condition that not only reduces operational efficiency and increases maintenance costs but raises safety risks. Preventive actions such as proper load distribution, clean and aligned rails, and routine checks are essential.

The Challenge



High wear and tear of crane wheels due to frequent contact of wheel flange against the rail.

The Solution

Inductive sensors can measure the offset and steer the crane towards center.

Off-tracking management reduces wear

  An off-tracking management system can prevent unwanted movement and align the crane flange with the rail center. This proven solution reduces wear and tear on wheel flanges and rails, improves the precision of crane traversal, and increases both safety and uptime by preventing jamming and tilting.

Data-driven decision making

Modern automated cranes generate gigabytes of data within minutes—and when multiple cranes operate simultaneously, this can quickly scale to terabytes. To make the data manageable and actionable, **intelligent data structuring** is essential. For example, separating operational data from maintenance data helps focus analyses for faster decision making.

- **Operational data** report throughput rates, active versus idle times, moves per hour, and so on, supplying the information needed to analyze key performance indicators (KPIs).
- **Maintenance-relevant data** include an overview of motion characteristics such as speeds, currents, and position, offering an at-a-glance view of the equipment's health status. The virtual representation of any given crane motion translates live data to a real-time on-screen copy.

To support effective decision making, **crane management systems** must structure both data types and present them clearly to the relevant users. Systems should provide both **local and remote reporting access**, enabling real-time monitoring and responses when needed. The interface must be intuitive and transparent, letting users identify issues early and reduce downtime.

Another critical requirement is **seamless, bidirectional data integration**. That means these systems should be able to both

- ingest data from third-party sensors and automation systems, and
- integrate with higher-level platforms such as cloud services and proprietary enterprise systems.

Such a structure ensures a **single source of truth**, thus eliminating the need to consult multiple reporting tools and also enhancing data reliability. Additionally, the system should support **optional advanced capabilities**—such as training AI models for predictive or preventive maintenance, replaying historical conditions for root cause analysis, or collecting the data needed for continuous improvement initiatives. These features should be **modular and configurable** based on user requirements.

Comprehensive remote visualization of crane management and terminal operations

Ultimately, **plant managers need a holistic overview** of their crane fleet. Crane management systems should offer a visual dashboard of KPIs across connected cranes, including metrics like performance efficiency, operating hours, optimal working conditions, mean repair time, and energy consumption. They should also allow users to generate reports suitable for audits and administrative purposes, **enabling data-driven decisions at every level of operation**.

ARTICLE: FROM INSIGHTS TO ACTION

Optimizing crane automation through data

Modern industrial facilities face complex challenges: managing crane process data, ensuring consistent product flow, meeting strict safety and environmental standards, and minimizing downtime. An intelligent crane management system makes it possible to transform these challenges into opportunities by **turning operational data into clear, actionable insights.**

Discover how integrated solutions help industrial operations work smarter, reduce downtime, and prepare for future demands—while keeping operations intuitive and efficient for everyone involved.

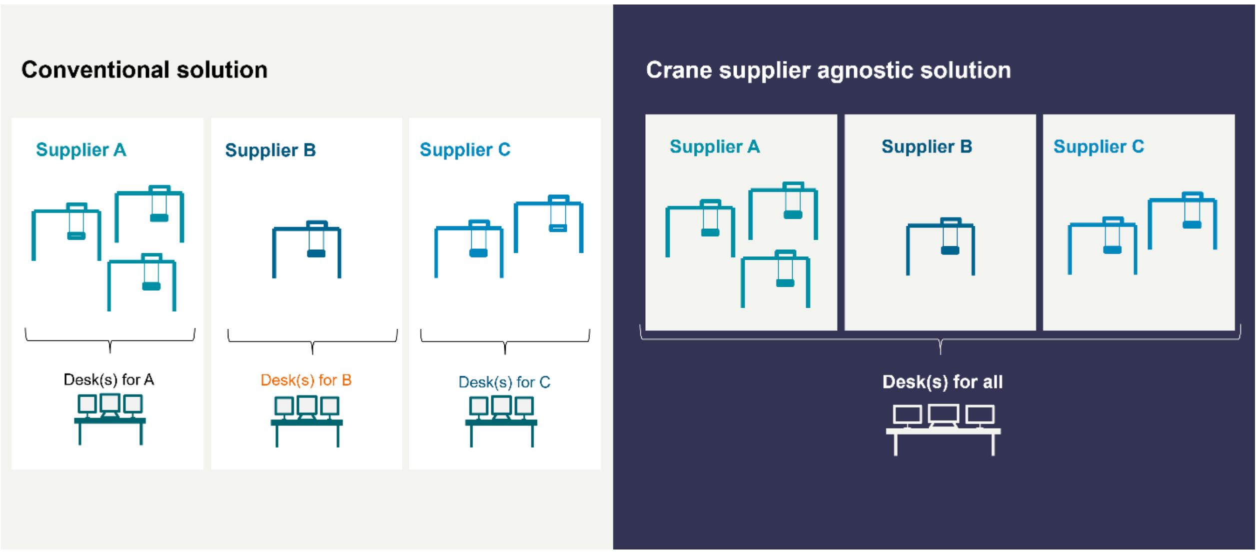
Explore this topic further in this article.

Remote-control systems for smarter and more sustainable operation

Remote crane operating systems (RCOS) are transforming industrial crane operations by letting operators control cranes from a centralized, safe, and ergonomic environment—far from the harsh conditions of the past, such as extreme heat, dust, or toxic fumes. These intelligent systems enable flexible connectivity: Any operator can control any crane from any desk and even manage multiple cranes simultaneously. With features like smart task pooling, decentralized architecture, and seamless integration across automation platforms and camera systems, the remote control system ensures uninterrupted performance and optimal resource use. The result? Reduced labor costs, improved safety, and greater operational flexibility—making remote operations not just a technological upgrade but a strategic advantage in modern crane automation.

Remote operation of cranes in an industrial setting

When selecting an RCOS, users should prioritize the system's **openness**—its ability to integrate seamlessly with automation platforms, regardless of the supplier. This vendor-agnostic approach supports independent procurement decisions while also simplifying maintenance and strengthening cybersecurity.

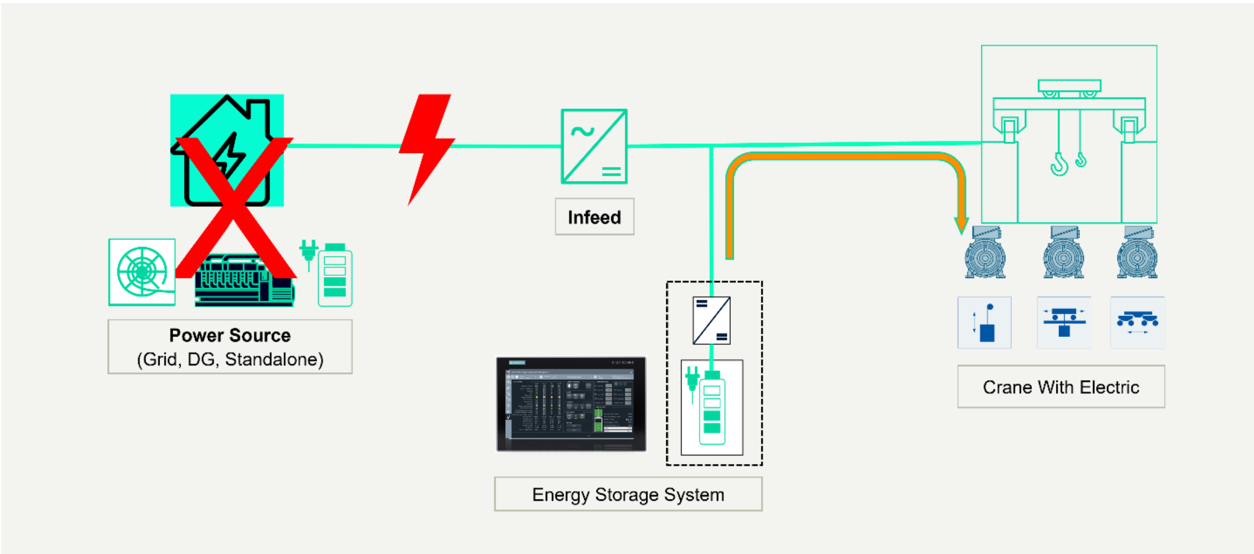


Vendor-agnostic RCOS connects to all cranes, regardless of supplier.

Additionally, using a **digital twin** of the crane allows teams to validate the design of a system design before it's deployed—for example, to ensure optimal placement of sensors and cameras. The twin also provides a safe environment for operator training before live operation.

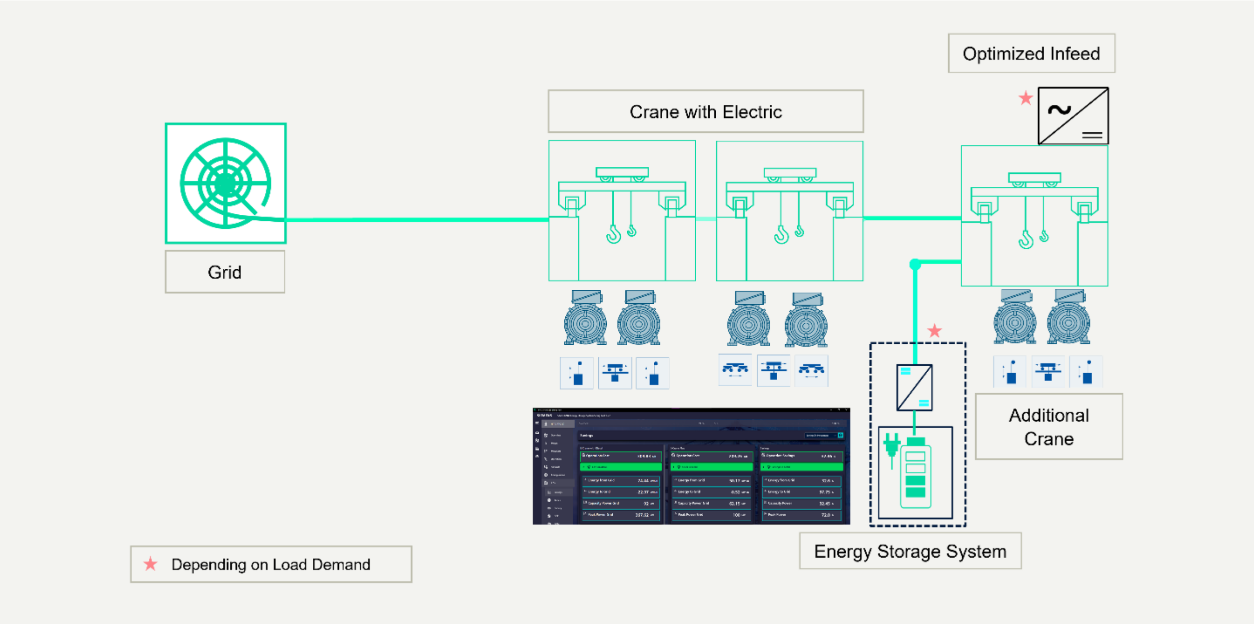
Energy management

Energy efficiencies are becoming a critical success factor in crane operations, especially in remote or high-demand environments. Imagine a scenario in which a crane stalls in midair due to a sudden power outage. Although rare, such interruptions can be costly and dangerous. An added energy storage solution can head off outages, ensuring uninterrupted operations by managing peak loads and providing reliable backup power.



Energy management through an added energy storage solution

Consider another scenario—expanding crane capacity within existing infrastructure. Here, battery-based energy storage can be incorporated to smooth energy usage by storing excess energy when loads are minimal and then using it during peak loads. This approach can avert a costly grid upgrade.



Load optimization with an energy management system

Justifying investment in automation

In large-scale industries such as steel manufacturing, cranes typically account for only **2%–5%** of the total plant investment. Despite their complex and indispensable role in material handling, cranes often face constraints in both the operational and capital budgets. Therefore, any automation proposal must clearly demonstrate the long-term value of crane automation—showing that **the benefits of improved performance, reduced downtime, and enhanced safety** outweigh the costs of equipment upgrades and operator training.

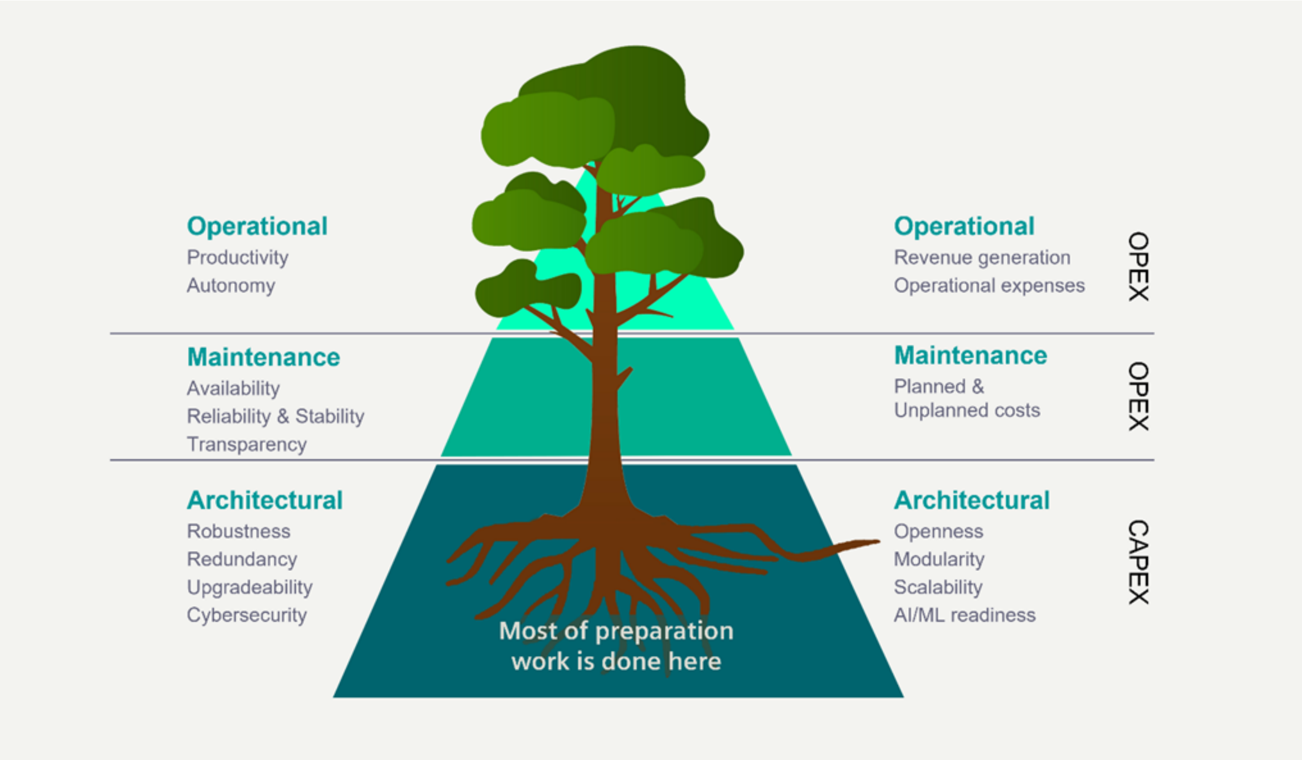
Are we doing the right thing?

When an organization considers investing in automation, it's not just about acquiring technology. It's about envisioning how well that technology will integrate into existing systems, improve operations, and deliver sustainable outcomes over time. This decision is rarely straightforward. There's always a balance to strike between the cost of investment, the technology to be implemented, and the risks involved.

For example, a plant aiming to increase throughput might consider two alternative paths:

- Invest in complete new subsystems with advanced features
- Introduce automated add-ons to reduce manual intervention

Both approaches aim to enhance productivity, but each carries its own risks in varied percentages—such as system compatibility, latency, spare parts availability, safety, and long-term maintainability.



The return on investment in crane automation is defined by its performance at the architectural level.

Organizations that have successfully embraced automation are now seeing consistent operational excellence, with improved KPIs and streamlined maintenance. But it's important not to overlook the critical groundwork laid at the architectural level that makes these outcomes possible.

Therefore, it's essential to take **a balanced, step-by-step approach** when evaluating the return on investment of crane automation—**not just in terms of absolute figures, but also in how smoothly the solution can be implemented and how well it can scale across operations.** Consider following these steps:

1. **Quantify targets with timelines**
   Set clear performance goals with realistic timelines. Where possible, leverage digital twins of machines or operations to simulate outcomes, validate assumptions, and monitor progress in real time.

   a. Define a scalable implementation process
      Establish a standardized road map for deployment and evaluation. A practical starting point is to select a crane whose workload is 90% standard operations or one that offers clear potential for scalability, ensuring early success and smoother adoption.

   b. Set measurable acceptance criteria
      Identify clear benchmarks for success—both technical and operational. Track metrics, such as the number of breakdowns versus downtime, over a defined period to assess system reliability and responsiveness.

2. **Adopt a stepwise approach to workforce development**
   Instead of discarding legacy installations, repurpose them as on-site training centers for new employees. Complement this arrangement with virtual simulators to upskill staff and support a smooth transition to automated systems.

3. **Enable continuous improvement and scalable growth**
   Design systems with open, modular architectures that can evolve with operational needs. Prioritize solutions that support future expansion with minimal hardware changes and comparatively low implementation effort.

The industry has recognized the need to implement automation: According to a recent report by Fortune Business Insights, the global autonomous crane market is projected to grow from US$6.3 billion in 2024 to US$40.9 billion by 2032, reflecting an impressive 26.3% compound annual growth rate.[1] This rapid expansion signals a major and rapid industry shift toward intelligent automation. Companies hesitant to invest in automation due to infrastructure concerns risk falling behind and losing competitive ground. The strategic question has evolved from "Should we automate?" to "How quickly can we adapt?"

Strategic adoption: Leading the future

With the technology now mature and readily available, the decision to automate is no longer a matter of feasibility—it's a matter of strategic direction: Lead the transformation or risk falling behind.
For organizations considering investment in crane automation, success hinges on reducing risks and optimizing capital expenditures. Though it does not require a massive overnight transformation, partnering with experienced automation providers can accelerate the journey even while enabling a smoother transition and long-term success. Through smart, strategic implementation strategies and collaboration with experienced partners, businesses that adopt a gradual approach—starting with pilot projects, leveraging simulation tools, and optimizing their automation ecosystem—will lead the next era of industrial efficiency.

[1] Source: https://www.fortunebusinessinsights.com/autonomous-cranes-market-106575

About the author
With over 13 years of diverse experience in various functions, industries, and international markets, Amrita Singh is driven by a passion for delivering tangible results and fostering positive change. Her expertise spans sales, project management, business development, partner management, and leadership of global strategic initiatives.
Growing up in a steel city in India, Singh witnessed firsthand the grit and resilience of people working in some of the harshest industrial environments. That early exposure shaped her career path, steering her toward the front lines of some demanding industrial settings to work closely with end users. This hands-on experience gave her a profound understanding of both the operational pressures and the perseverance required to keep things running. It also fueled her commitment to driving change through automation and innovation.
She is convinced that the crane industry is at a pivotal moment, when being open to piloting new ideas and technologies is not just an option but a necessity. Many of the toughest challenges still do not have clear answers. This is why collaboration, experimentation, and bold thinking are more important than ever. Singh aims to encourage others in the industry to embrace automation as a pathway to smarter, safer, and more sustainable operations—and to join in shaping what the next generation of industrial excellence looks like.

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Siemens empowers companies of all sizes within the process and discrete manufacturing industries to accelerate their digital and sustainability transformation across the entire value chain. Siemens' cutting-edge automation and software portfolio revolutionizes the design, realization, and optimization of products and production. Siemens automation and digitalization technology accelerates customer transformations with industrial AI, boosting efficiency in factories, enhancing city livability, and promoting sustainable transport solutions. As a trusted technology partner to the crane industry, Siemens commits to enhancing crane productivity through co-creation and customized solutions.
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