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Reimagining Factory Automation: The Winds of Change

A brief outlook on the core building blocks of factory automation in the future

A Frost & Sullivan White Paper

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THE NEED FOR A COGNITIVE SHIFT

Factory automation has played a pivotal role in the evolution of manufacturing from the early days of manual control through relays and switches to the advanced digital platforms that are seen today. Increasing productivity, achieving mass production, and improving efficiencies have been a perennial quest for manufacturers and have been catalysts for advancements in automation. We are at a crossroads once again as a new and vastly different era of automation dawns. In the 20th century, the principal driver of factory automation was mass production; in the 21st century, the driver will be manufacturers' need to manage rapid innovation cycles, complex personalization requirements, and intensifying cost pressures in a global landscape with stiff competition.

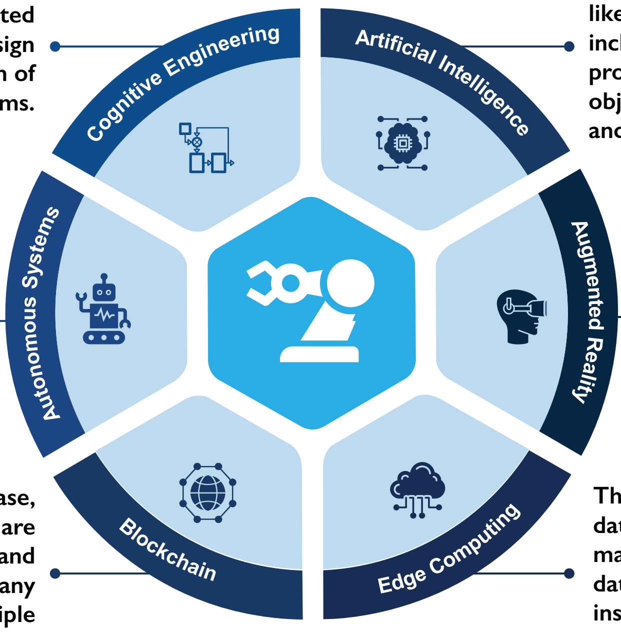
Many manufacturers that have enjoyed leading market positions with their legacy machines and production processes will soon find their value proposition either rendered obsolete or, at the very least, challenged by new competitors with innovative ideas. This demands a reimagining of factory automation: a new architecture that can meet the complexities and demands of the future.

For the industry at large, it is imperative to realize that this will be an immediate, tectonic shift rather than the gradual evolution seen in decades past. It will require a dramatic change in the way we perceive factory automation. Many of the rules are likely to be rewritten.

THE 6 LEVERS OF CHANGE

Frost & Sullivan has identified six levers of change that will redraw the approach to factory automation, as shown in Exhibit 1. Foremost is the ubiquitous use of artificial intelligence (AI), which is a collective term that refers to technologies including machine learning, deep learning, neural networks, and natural language processing. AI's role in automation could vary from supporting design teams to empowering control systems via machine learning algorithms that facilitate continuous process learning and improvements. AI primarily will deliver value in factory automation through machine learning that harnesses the vast amounts of product and process data that remains largely underutilized today.

Exhibit 1: The 6 Levers of Change



Cognitive Engineering: Application of cognitive psychology and related disciplines to the design and operation of human-machine systems.

Artificial Intelligence: An endeavor to create machines that can sense, process, and act like humans, with abilities including natural language processing; planning; image, object, and sound recognition; and problem-solving.

Autonomous Systems: Systems that can gain information about their environment, adapt and independently make decisions based on reasoning.

Augmented Reality: A technology that superimposes a system-generated image onto a user's real-world view. It deals with the real-time integration of digital information with the user's physical environment.

Blockchain: A distributed database, wherein transactions are securely encrypted and replicated across many computers in multiple copies of a ledger.

Edge Computing: The practice of processing data near the edge of a machine network (where the data is being generated), instead of in a centralized data processing warehouse.

Source: Frost & Sullivan

The worker of the future will not only have access to key performance indicators (KPIs) of production processes but will also be fed visual, immersive contexts in real time. Augmented reality (AR), the second lever, is poised to become a third eye for factory workers, providing greater visibility and guidance on the shop floor.

AR ON THE SHOP FLOOR

In a case example from Siemens AG, line managers can identify process anomalies (e.g., faulty machines) through an AR device that can virtually overlay KPI details on any machine in the production process. Information about KPIs that demand further action can be relayed to service technicians, who can then attend to the problem using instructions displayed as an overlay. The AR device also can connect to a remote expert who can guide the on-site technician with remedial steps in real time.

The next lever, edge computing, is a relatively mature concept that has already found its way into many factories. The idea of edge analytics is to expand the functional capacity of automation systems (e.g., programmable logic controllers or PLCs) without having to push all critical data to an external cloud. Besides saving time and effort, it also ensures localized data analytics, high processing speed, and robust cybersecurity.

PROCESS OPTIMIZATION THROUGH AI AND EDGE ANALYTICS

Siemens' Amberg factory, which produces 6 million SIMATIC products annually, employs a combination of AI, edge computing, and predictive analytics to improve the efficiency of its production lines. The factory previously used X-ray end-of-line testing, which resulted in longer lead times and higher remedial costs for defects. Through the new analytic method, the company was able to gather process information to predict the likelihood of manufacturing defects and qualify the need for quality testing. This helped to minimize the number of X-ray tests, thereby improving process efficiency and eliminating costly bottlenecks.

The next lever is blockchain. Traditionally referred to in the context of digital cryptocurrencies, blockchain is expected to expand its influence beyond financial services and into the manufacturing ecosystem, predominantly in the area of supply chain logistics. This lever is still in the nascent phase; however, its ability to automate processes, enable secure transactions or records, and bring transparency in the network offers many promising opportunities in factories of tomorrow.

Conventional automation systems enable low-level processes to run with little human intervention. Manufacturers could soon find themselves in a scenario where humans will not merely delegate tasks but work alongside another lever of change: autonomous systems that can also think and act. AI also will play a role in cognitive engineering, the final lever of change. It is likely that in the factory of the future, cognitive systems that combine human principles of knowledge, contextual awareness, and situational intelligence will allow for the automation of many engineering tasks. A cognitive engineering system will be able to perform analysis faster than a human, without fatigue, distraction, or forgetfulness.

Exhibit 2 shows how the six levers of change could effectively address today's limitations in factory automation.

Exhibit 2: Effects of the 6 Levers of Change on Automation

Current Limitation in Automation	Lever of Change	Impact on Automation	Evolution Phase (2019)
Machines have a low level of intelligence	AI	+ Process optimization + Intelligent automation + Heightened productivity	
Restricted environment for quality inspection and collaboration	AR	+ Streamlined manufacturing processes + Better collaboration + Enhanced simulation and visualization	
Low flexibility with high latency in data processing	Edge Computing	+ Data immediacy + Network security + IT simplification	
Manual and software-based management systems	Blockchain	+ Enhanced contract management + Quality control and accountability + Transparency and traceability	
Machines have limited mobility	Autonomous Systems	+ Collaborative working + Sensor and sensing integration + Learning and decision-making	
Machines have a limited ability to learn	Cognitive Engineering	+ Data integration and compliance + Cognitively capable machines + Improved competency	

Legend: Nascent — Evolving — Well developed

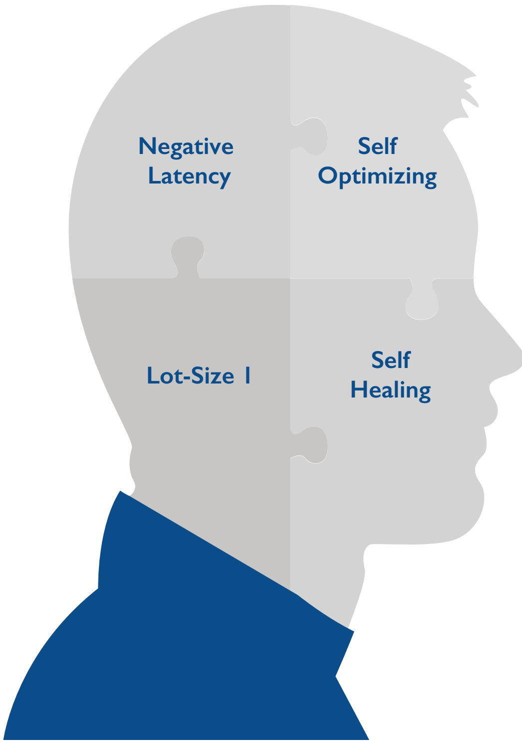
Source: Frost & Sullivan

The six levers of change will result in new factory automation architecture, supplanting conventional industrial hardware and software. That said, legacy machines will not become obsolete, though their value will be greatly diminished.

GENERATING VALUE

A discussion about the future of automation is not complete without evidence of the value it will bring, as shown in Exhibit 3.

Exhibit 3: Automation Value Drivers



Self-Optimising Factories
Production process that corrects itself pre-emptively with little or no human intervention

Self-Healing Assets
Factory assets that have the ability to self-diagnose and self-manage their health autonomously

Lot-Size 1
Creating a unique product experience for a given customer

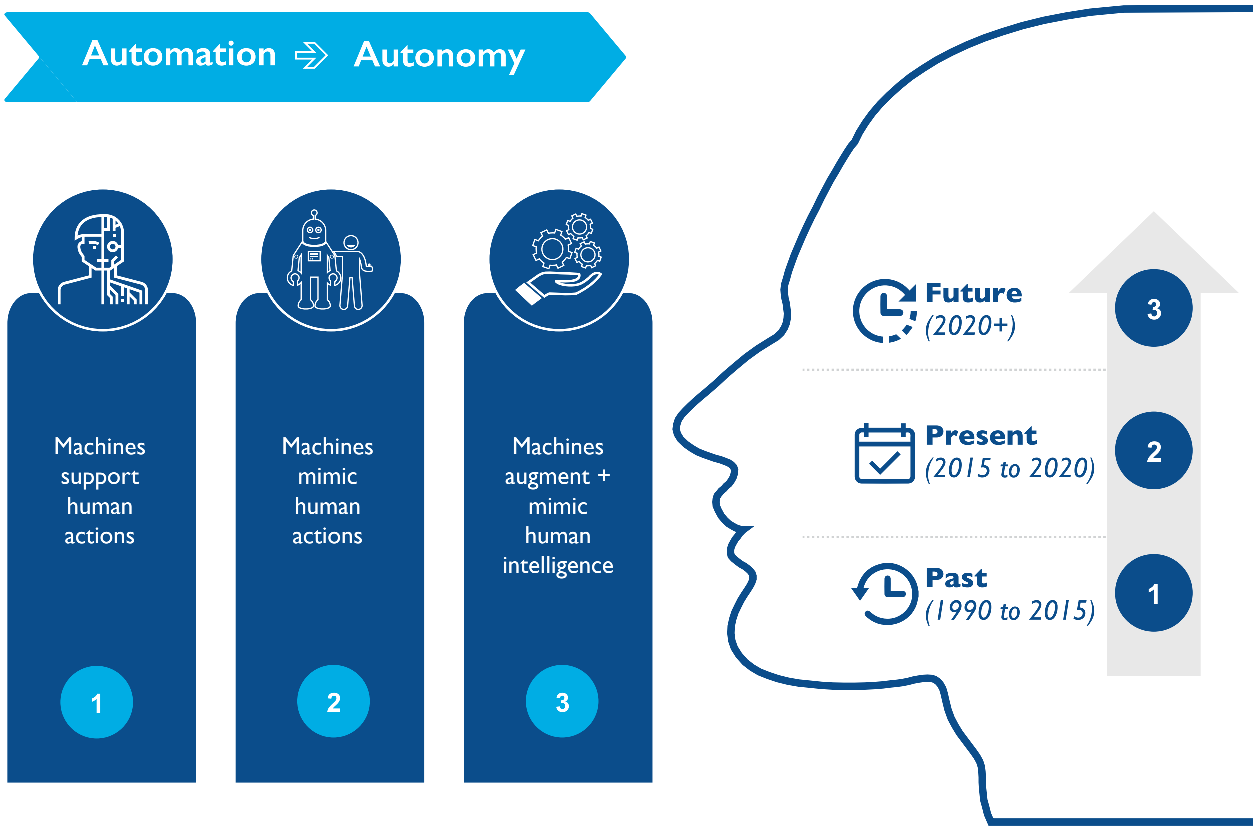
Negative Latency Manufacturing
A factory that operates "in tomorrow," today

Source: Frost & Sullivan

FROM AUTOMATION TO AUTONOMY

Autonomy gives each asset on the factory floor the decision-making and self-controlling abilities to take action independently in the event of a problem. Autonomous systems that are armed with a greater field of view and high degrees of mobility and operational flexibility are not entirely new. However, the scale of autonomous systems in the industrial environment is expected to grow manifold. Their use in factories presents the opportunity to increase productivity, flexibility, and reliability; to add value in a competitive arena; and to compensate for an aging workforce. Although the words sound similar, there is a substantial difference between automation and autonomy: while the former is more about executing a predefined task, the latter is more about how to execute a task by mimicking human behavior in a dynamic environment. For example, an automated robot is trained to perform a single, repetitive task, such as positioning a car panel in exactly the same place on each vehicle; an autonomous robot does this and carries out other independent tasks, such as moving the car panels from one place to another without the need for programming. The use cases of autonomous systems in a factory will vary. In some, the need may be to remove human involvement; in others, it may be just to augment a worker's physical and intellectual abilities.

Exhibit 4: The Evolution from Automation to Autonomy



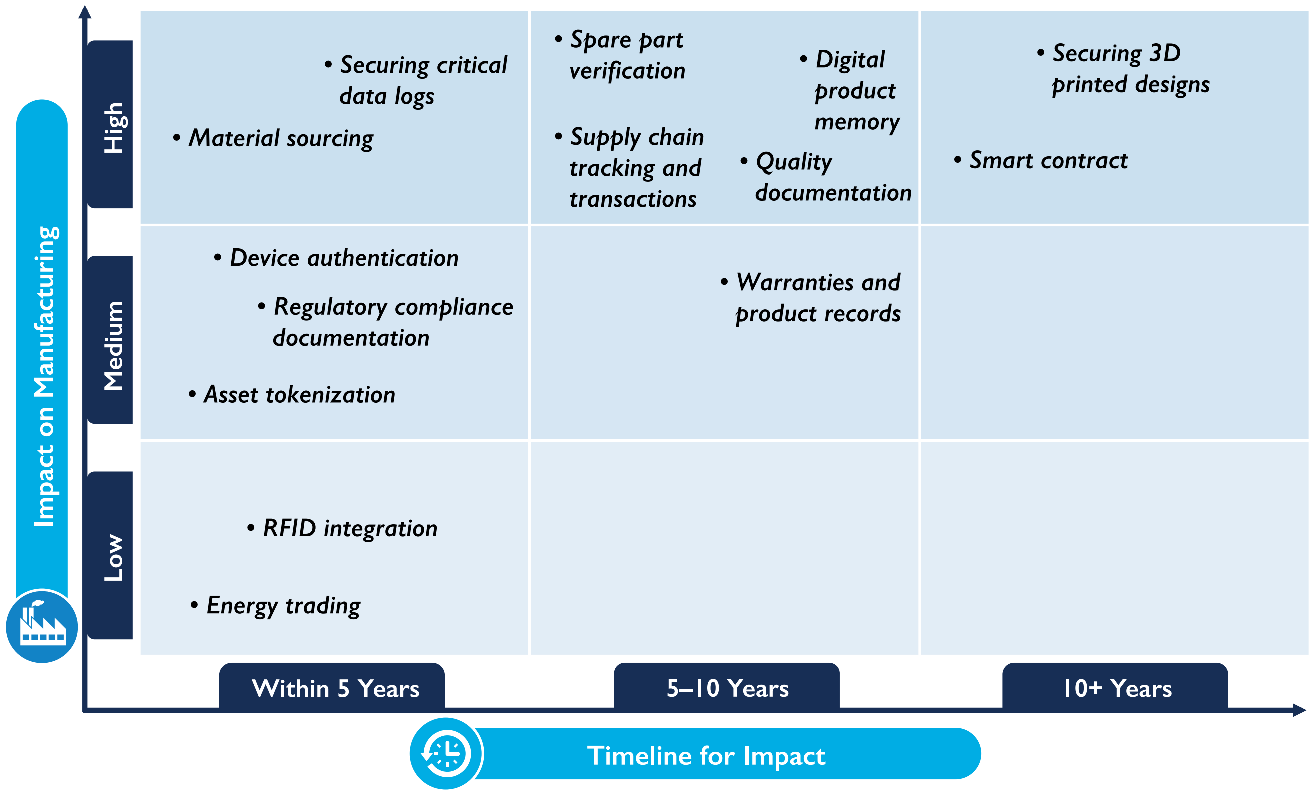
Source: Frost & Sullivan

Exhibit 4 illustrates the evolution of autonomous systems. Undoubtedly, it conjures up an image of a factory filled with self-moving, self-thinking, and self-governing machines. Industrial communication, e.g., Industrial 5G, is crucial for these applications. It provides ultra-reliable, ultra-low-latency communication for mobile real-time applications like automated guided vehicles (AGVs).

BLOCKCHAIN: THE OPPORTUNITY FOR DECENTRALIZED TRANSACTION PLATFORMS

The blockchain is an incorruptible, distributed digital ledger that can be programmed to record any digital transaction or information. The technology allows for the distribution of information from one party to another without the risk of being copied or manipulated and for both parties to arrive at a consensus on a common digital history without involving an intermediary. Frost & Sullivan identified the possible scope of blockchain applications in manufacturing, as shown in Exhibit 5.

Exhibit 5: Potential Blockchain Uses in Manufacturing



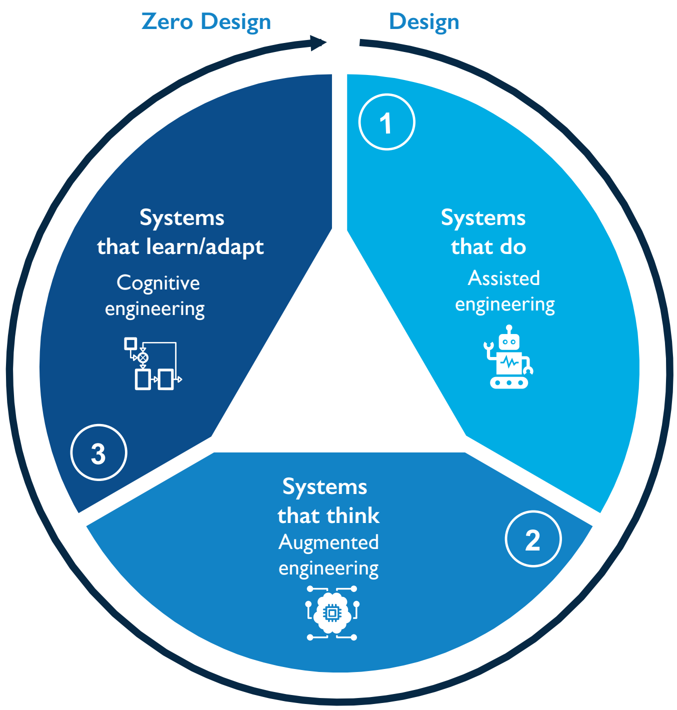
Source: Frost & Sullivan

Industrial enterprises exchange information related to designs, raw materials, manufacturing, delivery, and services with multiple stakeholders in locations around the world. The production of even one small component of a single product involves several levels of transactions in the form of material quotes, purchase orders, and design change requests; each requires a financial, regulatory, contractual, and trust-based relationship between two parties at any given point of time. Blockchain has the potential to resolve trust issues in the supply chain and enable various stakeholders to instantly begin trading without the need for a middleman or regulatory authority. From an automation standpoint, manufacturers can use blockchain technology to boost their innovative capabilities, slash inventory costs and turnaround times, distribute overcapacity, automate terms and pricing, and eliminate bottlenecks to meet global demand.

COGNITIVE ENGINEERING: THE MOVE TOWARD ZERO DESIGN ENGINEERING

Cognitive engineering is the application of cognitive psychology to the function of automation systems, bearing in mind process objectives to continuously optimize the way products are designed, processes are orchestrated, and production assets are managed. Exhibit 6 outlines the influence of cognitive applications on design engineering.

Exhibit 6: Cognitive Engineering System Evolution



System Attributes

1
- AI
- Natural language processing
- Self learning/optimizing
- Predictive

2
- Pattern recognition
- Ability to work with unstructured data
- Built-in knowledge repository

3
- Workflow implementation
- Process mapping
- Business process management

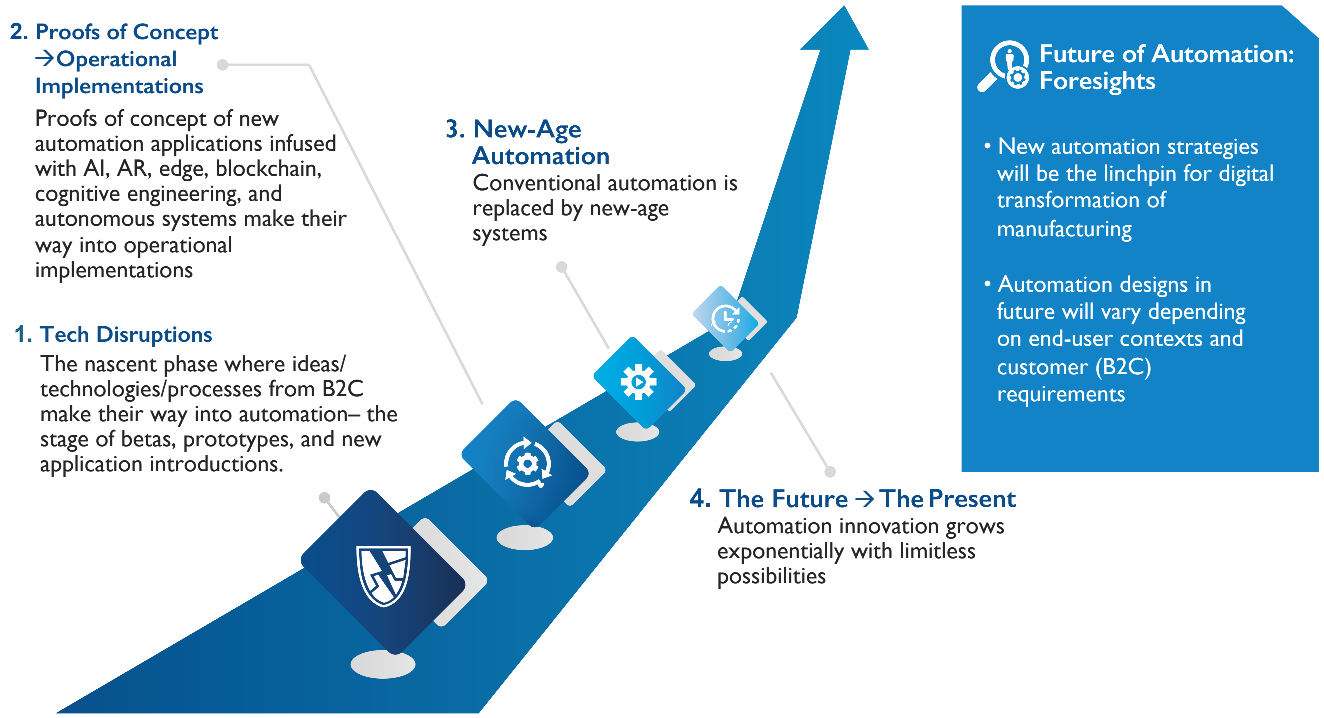
Source: Frost & Sullivan

The cognitive systems of tomorrow will include if-then algorithms that allow machines to learn from their own experiences. In effect, the function of design engineering could eventually become obsolete. Zero design engineering would be a key development that would alter the status quo across many manufacturing ecosystems.

APPROACHING THE FUTURE

Factory automation has always been a contentious topic. Our outline in this paper is to introduce the beginning of a new journey of factory automation in manufacturing—a disruptive change that will find its way due to the demands emerging in the consumer (B2C) landscape. Automation—a term that took hold in the middle of the 20th century—was meant to indicate a production process that made use of integrated machines. The wider adoption of industrial automation after the Second World War that led to an era of increased prosperity initially mired the workforce in economic anxiety related to fears that machines would replace people. The story today is unlikely to be any different. As a new automation paradigm takes root, the same sense of apprehension will re-emerge. The onus will be on industrial automation suppliers to define the paradigm with clarity and articulate the value that it can bring to a manufacturer. Exhibit 7 provides a chronology of expected developments at different stages of the automation journey.

Exhibit 7: The Journey towards Automation



Source: Frost & Sullivan

Although much of the topics discussed herein are still a work in progress, there is reasonable certainty that in the next three to five years, factory automation would have changed in its form and shape, significantly. While it is certain to cause a short-term jolt to legacy infrastructures in place, it will be a change that none can choose to ignore.

DISCLAIMER

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