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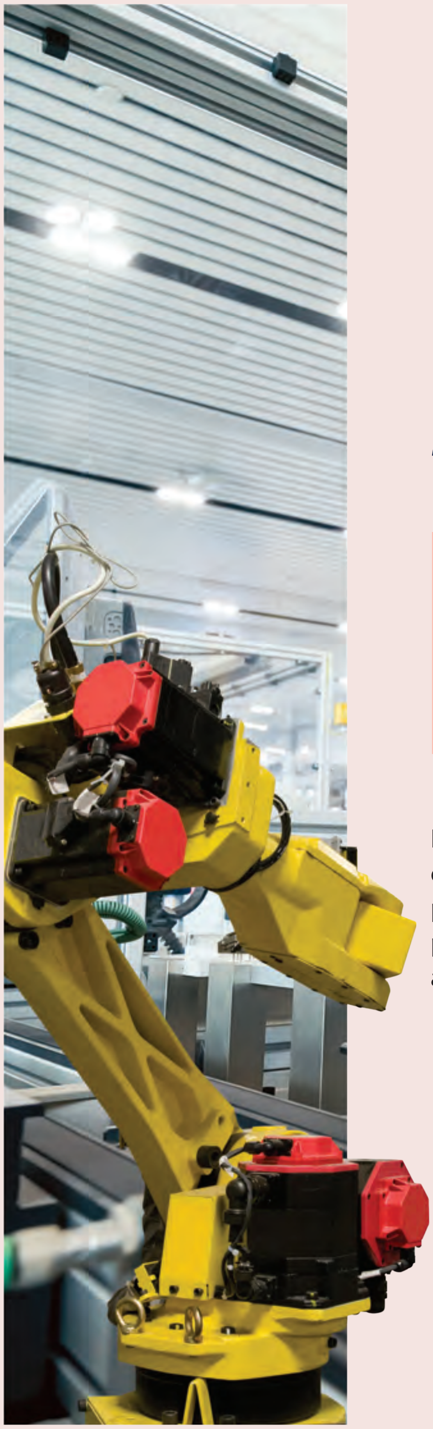


INDUSTRY 4.0 — A SYSTEMS APPROACH

Industry 4.0 adoption is too often hampered by the lack of clarity on its economic benefits for manufacturers. A narrow technical perspective for faster and cheaper processes misses the bigger picture. A holistic systems perspective is required to understand and implement Industry 4.0 and realize its immense potential.

Infosys Knowledge Institute

Industry 4.0 — a systems approach

Manufacturers face major changes to their traditional approach with the arrival of Industry 4.0, the fourth industrial revolution. Cyber-physical systems in a connected environment provide the incremental capabilities to realize the benefits associated with this revolution. In CPS implementations, physical and software components are deeply intertwined, through sensors and actuators connected to a controller. These systems produce products that are connected, autonomous and collaborative, interacting with each other based on the context. Software controls the physical mechanism with algorithms for decision-making, using data generated from operations.

Autonomous vehicles, intelligent process control, robotics and other expert systems are examples of combined cyber-physical systems. These cyber-physical systems of systems have significantly enhanced capabilities along with their inherent technological complexities and risks.

This paper explains the application of a unique approach to improve awareness and methods and overcome the increasing complexity of Industry 4.0 adoption for successful implementation and ongoing operation.

Adopting a systems approach

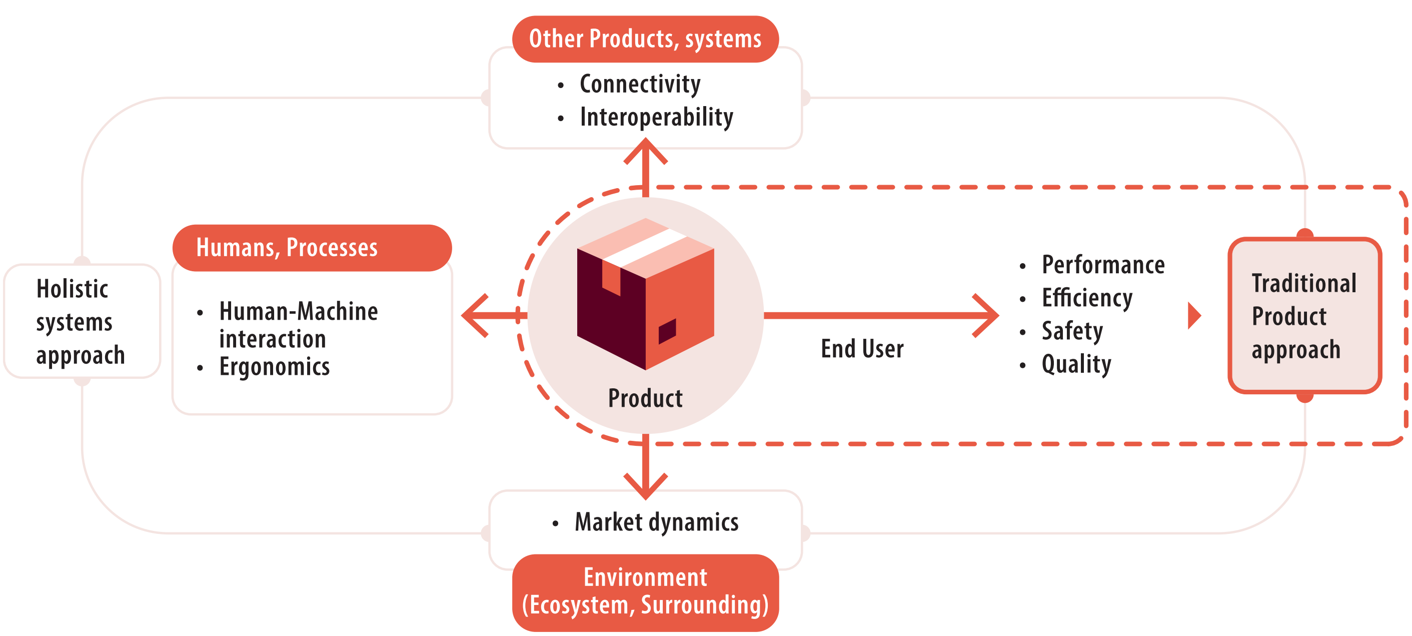
A common definition of a system in the IEEE standard is a "collection of *interacting* components organized to accomplish a specific function or set of functions within a specific *environment*." Systems approach is the science of deconstructing a complex system into a set of associated sub-systems and models that can be used to define, design, and draft the specifications of the larger system. These models offer an efficient way to identify, document, and communicate system aspects to multiple stakeholders, while reducing or completely eliminating the dependence on traditional approaches such as looking at it as one big overall system. Virtual models facilitate early testing and validation of system characteristics, enabling early understanding of properties and behaviors, for fast feedback on customer needs and decision points in the design process.

The systems approach shifts the focus to the solution and business outcomes. The solution is typically a system of products that interact with each other to solve a specific business problem for the end customer. This is critical in today's world, as we move from broad products sales to customer-specific customized sales that solve a real problem to address business outcomes. This approach is more profitable too as traditional products are discrete items aimed at large audience and become commodities quickly.

MIT Sloan School of Business Industry 4.0 program has developed a set of seven principles for systems thinking: observability, controllability, stability, metrics, feedback, variation and data.

Figure 1 shows the characteristics of a traditional product approach with its limited visibility to business benefits, compared with a much broader systems approach.

Figure 1. Product vs systems approach



Source: KRTI 4.0® Artificial Intelligence Framework for Operational Excellence

Motivation

Cyber-physical systems are dependent upon the convergence of computational and physical elements to represent a new class of technologically enabled systems.

In manufacturing specifically, CPS improves productivity and quality of shop-floor operations using smart prognostics along with diagnostics utilizing big data from sensors, machines, and systems on a network. Every physical component and system has a digital twin or a virtual model in cyber space. These models assist each component and machine to predict and prevent potential failure. They can self-predict, self-compare, self-reconfigure and self-optimize for robust and intelligent and performance.

At the same time, modern technological development is fueled by simultaneous advances in software, communications, computation, sensors, actuators, materials, data science and artificial intelligence, and their combinations. The emerging CPS will be a large complex system, with millions of potential points to failure, even after defining the "right system."

These new risks are a big challenge due to the functional divide between disciplines. Some disciplines have a definite barrier, with distinctly different requirements, technology, standards and cultures, and have not been talking to each other in the past.

For example, most industrial control devices do not run on open source systems like Unix or Linux. They are based on proprietary technologies designed by specialized operational technology manufacturers like GE, Honeywell, Siemens, and Schneider Electric. These devices are designed to last for decades, are still operational and will not be easily replaced. Given this hard constraint, it is vital to design and execute technical activities across multiple disciplines to remain coordinated, interoperable, distributed, and connected.

In a recent interview, Daimler Chairman Dr. Dieter Zetsche discussed the automotive industry's massive transformation, with a car becoming a super computer. According to Dr. Zetsche, the earlier success of the automotive industry is now becoming its challenge and it needs new capabilities. Daimler's challenge is to take mobility to the next level. Dr. Zetsche talks about a new form of innovation where timing and perfection are vital. Cars are evolving from objects to computers generating a lot of data. This transformation is a shift from a product perspective to a systems perspective.

Technology vs systems approach

Industry 4.0 is not only adoption of individual technologies. Organizations that have such a perspective will miss the big picture.

3D printing for example should not be seen through a narrow prism as a way to manufacture parts faster, on demand. Instead, design for additive manufacturing is an opportunity to take a fresh look at the basic design of parts, sub-systems and systems to improve functionality and performance. Parts were originally designed within the constraints of traditional manufacturing processes like casting, forging, welding and machining. Manufacturers are using new technologies and approaches to transform traditional processes and mindset, as in the following examples:

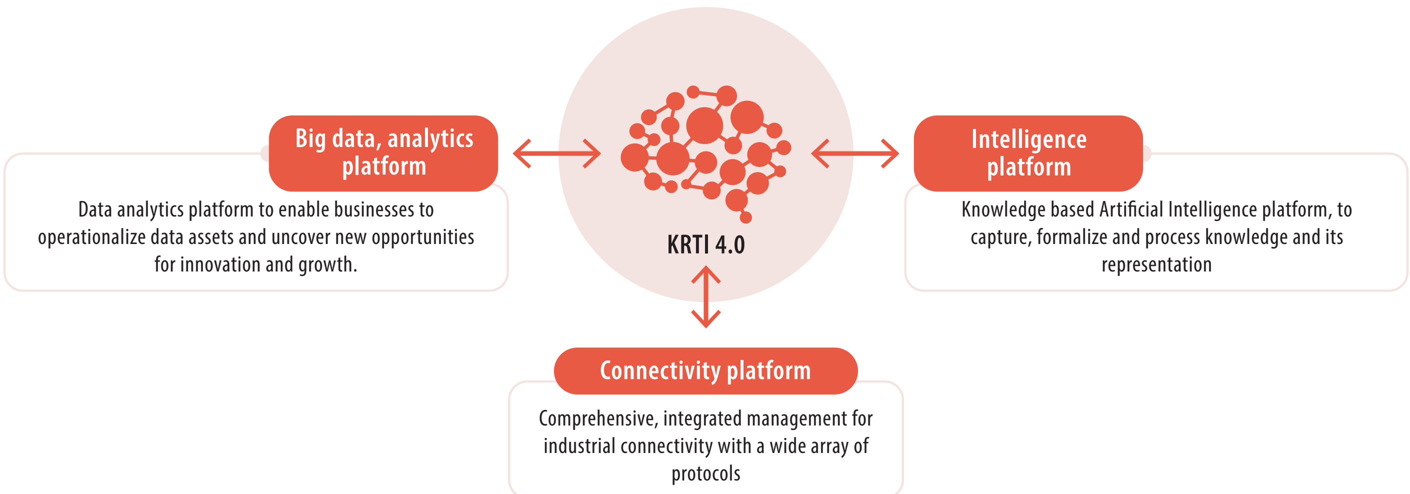
- GE Aviation applied DfAM to the fundamental redesign of critical parts for the fuel nozzle in jet engines to improve fuel efficiency and emission. The original assembly consisted of 20 parts with complex internal geometry. The nozzle was redesigned for additive manufacturing, shrinking the 20 parts into one. The new design resulted in five times the original durability and 25% less weight.
- A root cause in Boeing's 737 Max issue was a compartmentalized approach, as reported in the media. According to analysts, the original MCAS aircraft maneuvering system relied on data from multiple sensors to measure parameters such as the plane's acceleration and angle against wind. This did ensure the software did not act erroneously. But in the upgraded system, to avoid stalling in all types of situations, MCAS was allowed to control pitching of the flight by pushing down the nose. But data from only one sensor for the plane's angle of attack was used, removing the earlier compensating redundancies. A systems perspective during design and testing of the new system would have required that MCAS was tested under multiple scenarios to identify the failure modes.
- Seating systems supplier Adient looks at seats as products beyond the basic passenger safety and comfort. During its press release to announce their joint venture with Boeing, Adient explained how emerging trends in the automotive industry were leveraged to develop futuristic aircraft seating products.

Adient was interested in how seats interact with passengers to give a greater degree of comfort, innovation, features and functions. Comfort can be extended to avoid motion sickness and offer relaxing positions. Their seating designs integrate advanced design, comfort, safety, security, craftsmanship and material quality for interior airline cabin harmony. Comfortable seating arrangements in an aircraft create optimum seating experiences throughout the flight, whether reclining, working, eating, watching entertainment or sleeping.

A framework for operational excellence

The KRTI 4.0® AI Framework for Operational Excellence provides guidance on the systems perspective for a manufacturing environment. Built on the Infosys AI platform, KRTI 4.0® delivers system level modeling, analysis and optimization capabilities during the entire life cycle of an asset or a plant. The framework leverages Pöyry's Reliability, Availability, Maintainability, and Safety (RAMS) modeling expertise, integrated seamlessly with AI capabilities. It is powered by secure and persuasive network connectivity. It eliminates risks that were unknown and may not have been thought of during initial stages of plant design such as downtime of a particular system caused by degradation after ongoing operation, incomplete specifications or quality issues. Figure 2 is a simplified representation of the KRTI 4.0® architectural framework.

Figure 2. KRTI 4.0® architectural framework



Source: KRTI 4.0® Artificial Intelligence Framework for Operational Excellence

Infosys implemented industrial internet of things, a component of Industry 4.0, in its campuses to optimize energy consumption. Diverse assets including chillers, generators, sewage treatment plants, elevators, solar power plants and office spaces were connected using sensors to measure key parameters. A central command center was established for remote monitoring, control and preventive maintenance. Digital twins were implemented to compare systems as-designed against their actual performance and to conduct what-if scenarios under different conditions. A systems perspective was fundamental to achieve the unified energy conservation goals for this diverse family of equipment. This resulted in a 46% reduction in per-capita power consumption over 8 years and $100 million savings in 3 years.

The Industry 4.0 Maturity Index* developed by Infosys in collaboration with Aachen University and the acatech consortium considers efficiency as the primary value driver.

To look at production operations efficiency by measuring only performance and maintenance metrics yields a narrow, product-centric perspective. A systems perspective requires that other efficiencies are considered, and these include engineering for product design, information technology, energy usage and post-sales services.

Conclusion

A systems perspective has the compounding effect to amplify the benefits of multiple systems working together in unison, much greater than what they can achieve independently. This perspective does not restrict a local optimal solution but seeks a comprehensive optimum at the enterprise level. Leaders with a systems perspective will articulate the benefits of Industry 4.0 adoption to build a stronger and more convincing business case. And a strong business case, with technically sound assumptions, is an effective starting point for successful Industry 4.0 implementation.

References

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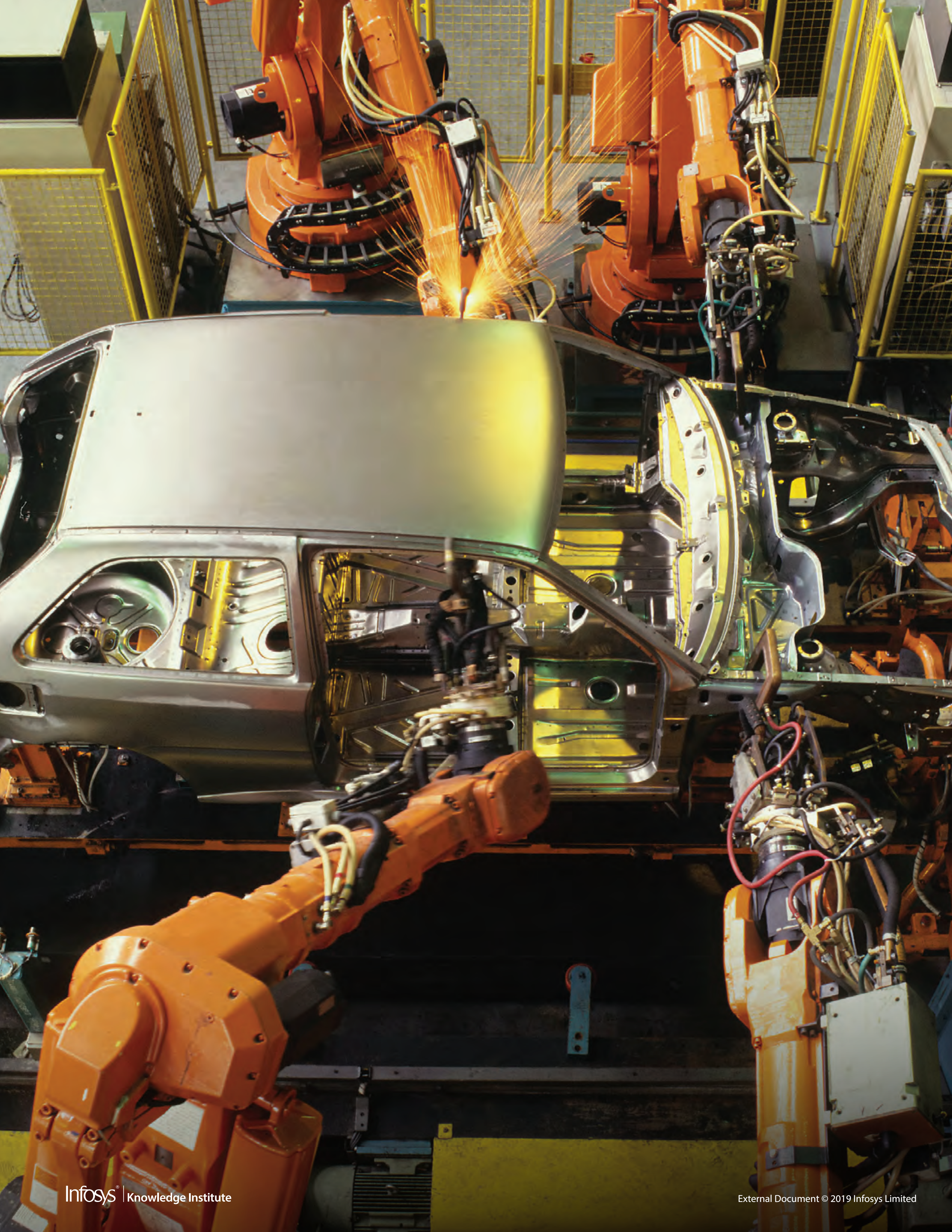

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