



Technological Disruption and the Future of Labour Market

Adi Darmadi

President Director, Rockwell Automation Indonesia, Indonesia

Abstract.

This paper discusses the transition from industrial automation towards autonomous operations amid global fragmentation, strategic protectionism, cybersecurity challenges, digital sovereignty, and changing supply chains. The presentation explains how software-defined automation, artificial intelligence, digital twin technology, and integrated robotics contribute to safer operations, improved decision-making, higher productivity, and greater operational resilience across manufacturing, mining, oil and gas, power generation, logistics, and related industries. It further highlights the progressive evolution from pre-digital operations to autonomous plants, demonstrating that technological transformation should advance together with workforce transformation. Findings presented from the 11th Annual State of Smart Manufacturing Report indicate that intelligent systems are intended to augment human capabilities rather than replace them, while organisations increasingly invest in workforce reskilling and capability development. For Indonesia, responsible automation provides opportunities to expand industrial capacity, attract investment, improve competitiveness, and create higher-quality employment. The presentation concludes that technological innovation and workforce development should progress simultaneously to strengthen sustainable industrial growth.

Keywords: Artificial Intelligence, Autonomous Operations, Industrial Automation, Smart Manufacturing, Workforce Reskilling.

Corresponding Author:
Adi Darmadi

Email:
adarmad@ra.rockwell.com

This article, authored by [Adi Darmadi](#), is published under the terms of the [Creative Commons Attribution-ShareAlike 4.0 International Licence](#), which permits unrestricted use, distribution, and reproduction in any medium, provided that proper credit is given to the original author(s), the title of the work, the journal citation, and the corresponding DOI. The selection and peer-review of this article were conducted under the responsibility of the JGF Conference Committee.



Published by Lemhannas Press.

Introduction

Industrial operations are entering a new phase in which conventional automation is progressively evolving towards autonomous operation, driven by advances in software-defined automation, artificial intelligence, integrated robotics, and digital connectivity. These technological developments are transforming the way industrial facilities are designed, operated, and maintained while enabling higher levels of operational efficiency, flexibility, safety, and resilience. Manufacturing, mining, oil and gas, power generation, logistics, water management, and other industrial sectors are increasingly adopting intelligent systems that support more adaptive and data-driven decision-making throughout the operational lifecycle.

These developments coincide with broader changes in the global environment, where supply chain disruption, strategic protectionism, digital sovereignty, and geopolitical fragmentation are reshaping industrial priorities. Organisations are therefore expected not only to improve productivity but also to strengthen operational resilience by adopting technologies capable of responding more effectively to increasingly complex operating conditions. Within this environment, autonomous operations represent the next stage of industrial transformation, extending beyond programmable automation by enabling intelligent systems to interpret operational conditions, generate recommendations, and support decision-making with minimal human intervention.

The presentation further emphasises that technological transformation should be accompanied by workforce transformation. Rather than replacing human resources, intelligent technologies create opportunities for redesigning work, strengthening technical capabilities, and expanding higher-value occupations. Consequently, industrial competitiveness increasingly depends upon the ability to integrate technological innovation with continuous workforce development through reskilling, capability enhancement, and closer collaboration between technology and human expertise. For Indonesia, this transformation offers significant opportunities to strengthen industrial capacity, improve productivity, enhance workplace safety, and support sustainable economic growth through a more competitive and highly skilled workforce.

Result and Discussion

The presentation outlines the evolution of industrial technology through four successive industrial revolutions before introducing the transition towards autonomous operations. Industry 1.0 was characterised by mechanisation, followed by Industry 2.0 through the introduction of electricity and mass production. Industry 3.0 introduced programmable

automation and industrial computing, while Industry 4.0 incorporated digitalisation, connectivity, and data integration. The current period represents an inflection point in which industrial operations are progressively moving beyond conventional automation towards autonomous operations. Unlike traditional automation, where systems execute predefined instructions, autonomous operations apply data, analytics, and artificial intelligence to interpret operating conditions, recommend actions, and, where appropriate, respond automatically.

The transformation towards autonomous operations follows a progressive pathway rather than occurring as a single technological leap. Industrial facilities commonly evolve from pre-digital environments characterised by predominantly manual processes towards digital silos, where individual systems become digital but remain disconnected. The next stage establishes connected operations through greater integration of operational data, followed by predictive operations that anticipate operational issues and support more informed decision-making. The final stage is autonomous operation, where intelligent systems become increasingly adaptive, highly integrated, and capable of continuously optimising operational performance. Throughout this transformation, the objective remains to support people rather than replace them by enabling safer working environments, higher productivity, and greater emphasis on higher-value responsibilities.

Achieving autonomous operations requires the integration of several complementary technologies. Software-defined automation provides operational flexibility by separating software from hardware, enabling systems to be configured and modified more efficiently. The presentation illustrates this capability through digital twin technology, which creates a virtual representation of industrial operations. Digital twins enable organisations to simulate, test, validate, and optimise operational changes before implementation, thereby reducing operational risk while improving planning and system performance.

Artificial intelligence further strengthens industrial performance across the design, operation, and maintenance phases. During the design phase, AI assists in generating and validating system logic, configurations, and operational behaviour more efficiently. During operations, AI supports production planning, material movement, sensing, process optimisation, and operational control. During maintenance, AI continuously analyses equipment conditions, predicts potential failures before breakdowns occur, and improves equipment availability through more effective maintenance planning.

The presentation also demonstrates the practical application of artificial intelligence in quality inspection through computer vision systems capable of identifying product

anomalies and defects that may occur infrequently but nevertheless affect product quality. This capability improves inspection speed, consistency, and overall quality assurance. In process industries, including mining, oil and gas, chemicals, petrochemicals, power generation, and manufacturing, artificial intelligence combined with advanced analytics enables simultaneous analysis of multiple operational variables, allowing earlier detection of operational constraints and supporting more stable, efficient, and reliable production processes.

Artificial intelligence also plays an important role in predictive maintenance. By analysing work orders together with equipment operating data, intelligent systems identify anomalies, forecast maintenance delays, and anticipate spare-part requirements before failures occur. This approach enables maintenance activities to shift from reactive responses towards proactive planning, reducing unplanned downtime while improving operational reliability and asset performance.

The presentation further introduces integrated robotics through Autonomous Mobile Robots (AMRs), which automate repetitive material-handling activities traditionally performed manually. The application of AMRs improves workplace safety, reduces operational errors, increases efficiency, and enables employees to concentrate on activities requiring greater technical judgement and problem-solving capability.

Workforce transformation constitutes an equally important component of industrial transformation. Findings presented from the 11th Annual State of Smart Manufacturing Report, based on a global survey of 1,500 industrial and manufacturing leaders, demonstrate that intelligent technologies are intended to augment rather than replace human capabilities. As intelligent systems become embedded within daily industrial operations, workforce roles and competency requirements continue to evolve. The presentation reports that 93% of surveyed organisations anticipate substantial workforce transformation, while 40% have already implemented workforce reskilling initiatives. These findings reinforce the importance of investing simultaneously in automation technologies and human capability development.

Three principal workforce implications are emphasised. First, work itself is being redesigned as repetitive and hazardous activities become increasingly supported by intelligent technologies. Second, workforce reskilling has become a core organisational capability accompanying technological transformation. Third, Indonesia possesses significant opportunities to expand industrial capacity, strengthen competitiveness, attract investment, and create higher-quality employment through responsible adoption of automation and autonomous operations. Accordingly, technological advancement should enhance industrial

capability and job quality rather than simply reduce labour costs.

Conclusion

The presentation concludes that autonomous operations represent the next stage of industrial transformation, integrating software-defined automation, artificial intelligence, digital twin technology, advanced analytics, and robotics to improve productivity, operational resilience, workplace safety, and decision-making across industrial sectors.

The discussion highlights three principal messages. First, industrial work is being redesigned as intelligent technologies increasingly undertake repetitive activities while enabling workers to focus on higher-value responsibilities. Second, workforce reskilling should become a core organisational capability accompanying every stage of technological transformation. Third, Indonesia has substantial opportunities to strengthen industrial competitiveness by expanding industrial capacity, attracting investment, and creating higher-quality employment through responsible adoption of automation and autonomous operations. Technological transformation should therefore strengthen industrial performance while simultaneously improving workforce capability and job quality rather than serving primarily as a mechanism for reducing labour costs.

Publication Note

This article presents an academic adaptation of the presentation delivered at the 10th Jakarta Geopolitical Forum (JGF X) 2026. Editorial revisions were limited to structure, language, and readability, while the speaker's original arguments, meaning, and policy recommendations remain unchanged.

References

1. Lembaga Ketahanan Nasional Republik Indonesia (Lemhannas RI). **Jakarta Geopolitical Forum X/2026: Strengthening Multilateralism: Survival Amid Global Turbulence and a Fragmented World** [video on the Internet]. Jakarta: Lemhannas RI; 2026 Jul 9 [cited 2026 Jul 17]. Available from: <https://www.youtube.com/watch?v=IbYayky-FmQ>