



# Innovations driving Industry 4.0 in Asia Pacific & Japan

Whitepaper

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## 1. Executive Summary: The Factory of the Future

The First Industrial Revolution used steam power and iron-making to mechanize production. The Second saw mass production that was powered by combustion engines, electricity, assembly lines, and telecommunications. The Third Industrial Revolution had microprocessors, software, mobile devices, and the Internet bringing about the Information Economy. Now a Fourth Industrial Revolution – or ‘Industry 4.0’ – is transforming factory operations and blurring the lines in physical, digital, and human interaction.

To cope with shareholder demands for growth despite increasingly fickle consumer tastes, price sensitivity, and a need to offer higher wages with better working conditions, manufacturers in Asia are investing in emerging technologies to unleash efficiencies and unlock new capabilities.

Manufacturing is becoming increasingly digitized and connected, and at an exponential rate. Factories of the future are becoming more productive, efficient, flexible, and safer.

- **Product development.** Smart wearables enabled with augmented, virtual or mixed reality will allow customized and virtual designs. 3D printing will facilitate the production of customized products and tools on-demand, especially where inventory holding or downtime costs are high.
- **Manufacturing and testing.** Connected production equipment can gather and share large amounts of data to facilitate cooperation to a much higher degree. Big data analytics and artificial intelligence (AI) can help reduce disruptions in production lines with high unplanned downtime costs, which is especially pertinent in industries such as automotive, aerospace, food manufacturing, paper, petrochemicals, and shipping.  
Autonomous robots, drones, and vehicles will increase workforce productivity and working conditions.
- **Procurement and warehousing; Order fulfilment.** Real-time asset tracking via wireless sensors will enable dynamic production planning between customers and suppliers and dynamic capacity scaling.

To achieve the vision for the Factory of the Future as in Figure 1, reliable, secure, low latency, high bandwidth, and interoperable network connectivity is pertinent. In addition, as the number and types of sensors multiply, the management of these devices, as well as the data collected will require an intelligent, multi-access, and secure platform for factories to control manufacturing operations.

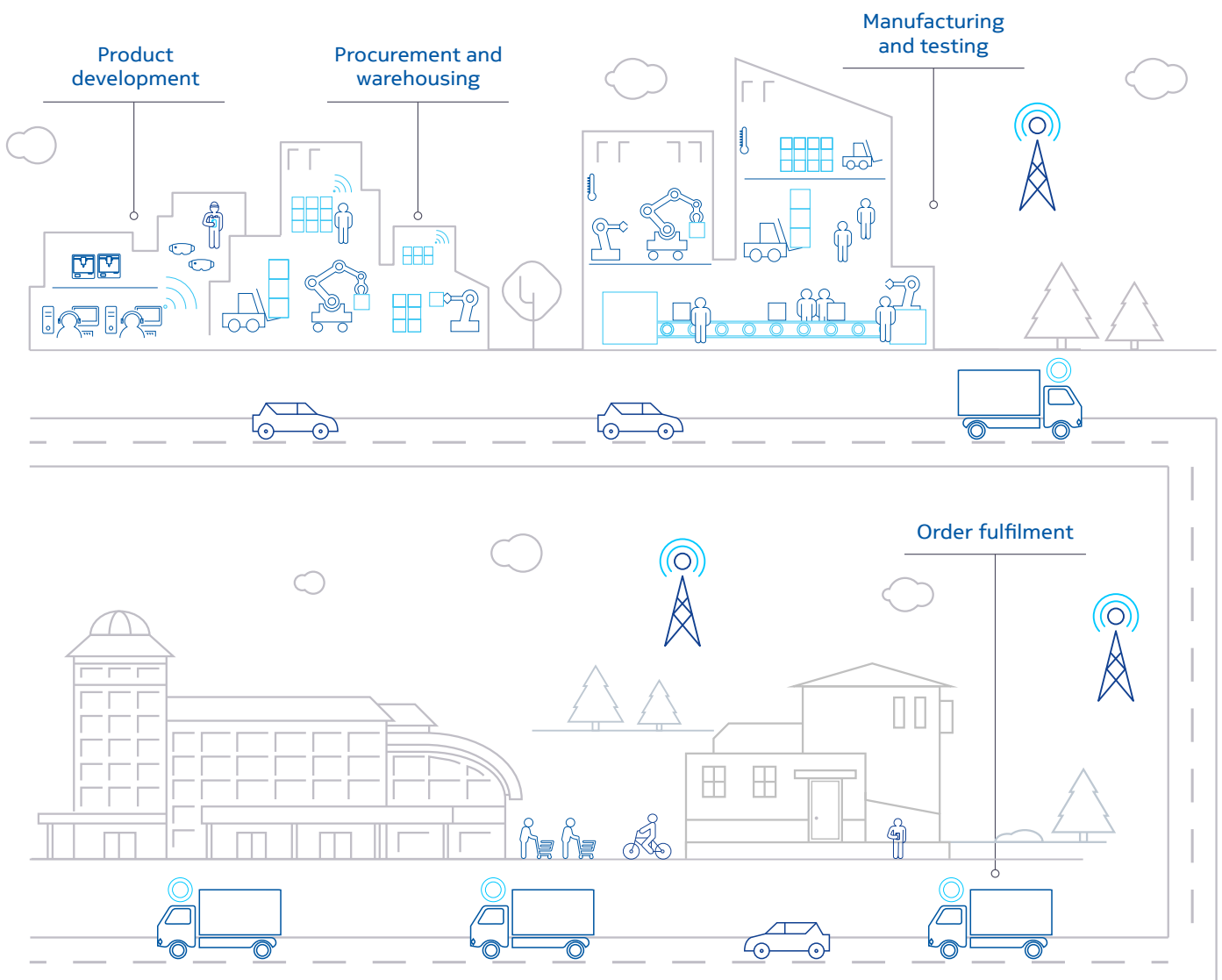


Figure 1. A vision for factory of the future

## 2. Industry 4.0 in Asia

### 2.1 Why Asia?

The Asia Pacific region accounts for one-third of the world's Gross Domestic Product (GDP) and is projected to grow at an average annual rate of 4.5%, driven by rapid urbanization and industrialization. As seen in Figure 2, manufacturing contributes between 16% to 29% to the GDPs of five key manufacturing hubs in the region – Indonesia, Japan, South Korea, Thailand, and Vietnam. A robust manufacturing industry is absolutely vital to support the growth of Asian economies.

Advanced Asia Pacific markets such as Australia, Japan, and South Korea have been investing heavily in centres of innovation and are positioning themselves as testbeds and producers of Industry 4.0 technologies, arising from government co-investment, advanced network infrastructure, and skilled workforce development. As a result, the GDP per hour worked at these markets exceeds that of the US. The level of technological advancement among production facilities in developing Asia Pacific remains uneven, as government policies, infrastructure, technical skills, and research and development (R&D) investments vary significantly. Specifically, Thailand, Indonesia, and Vietnam, the only three developing Asia Pacific countries ranked within the top 20 of Global Manufacturing Competitiveness Index, are poised to take on increasingly important roles as China pivots towards higher value manufacturing, and manufacturers seek alternative production sites near to the region's emerging consumer markets.

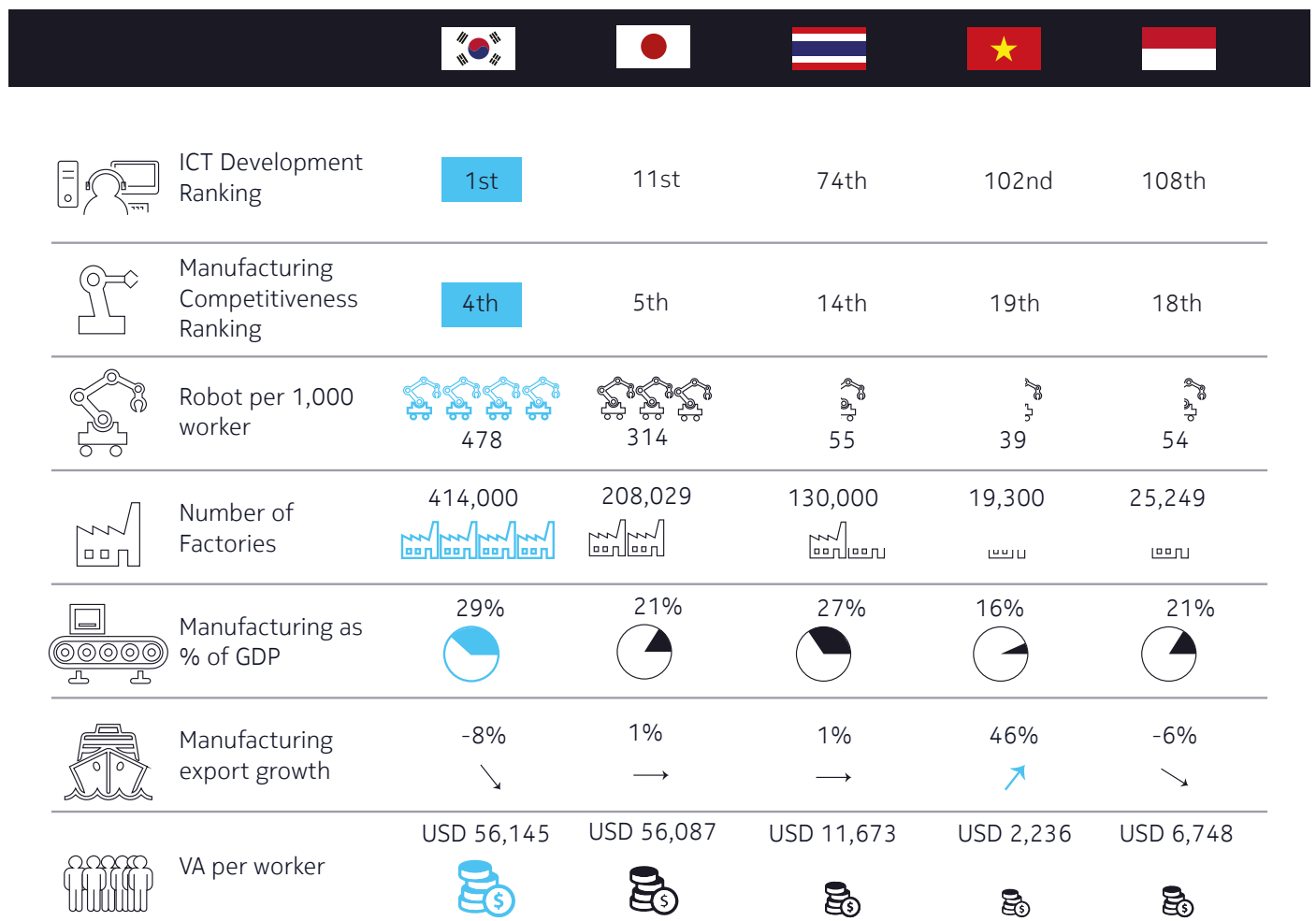


Figure 2. Manufacturing in key Asian markets

Our research identifies three key drivers that are accelerating the development of Industry 4.0 in Asia.

1. **Asia faces mounting pressure to increase productivity.** The economic imperative to improve productivity is driving many Asia Pacific countries to explore Industry 4.0 technologies today. For example, traditionally cost-competitive sectors like Vietnam's garment and textile industry is facing intensifying price competition from countries such as Laos, Cambodia, and Myanmar, as labour costs in Vietnam have grown by 45% in the last five years. On the other hand, developed markets like Japan face labour shortage due to a rapidly-ageing population. To remain competitive, manufacturers in both Vietnam and Japan are innovating to deliver better productivity.

2. **Public leadership as an effective catalyst.** Asia Pacific governments are taking the lead to encourage the adoption of Industry 4.0 technologies, with sector planning and incentive schemes, R&D investments, international partnerships, as well as infrastructure developments. For example, Korea’s Ministry of Trade, Industry & Energy announced plans in February 2017 to co-invest USD 80 million to increase the number of Smart Factories in the country from 2,800 in end-2016 to 5,000 before end-2017, and to 10,000 by 2020. Other similar initiatives driven by regional governments can be found in Figure 3.

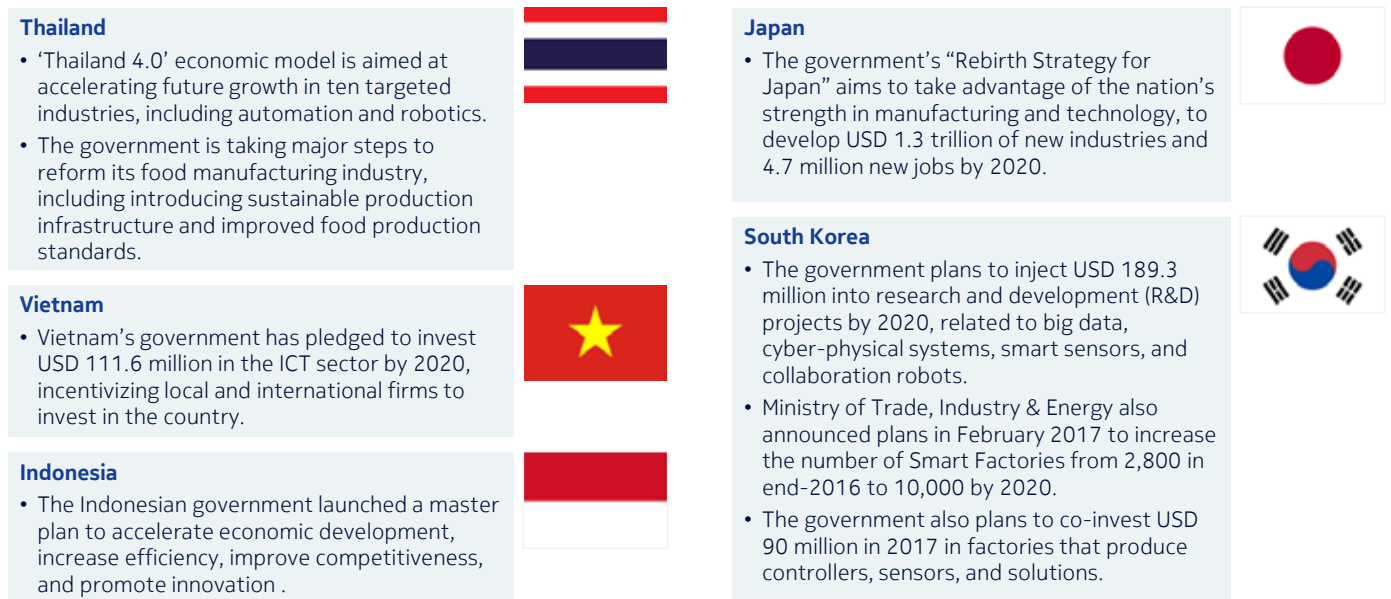


Figure 3. Public leadership as an effective catalyst

3. **International business is leading to technology transfers.** The adoption of Industry 4.0 technologies is often the result of domestic players tooling up for the export market. For example, Thailand’s Food & Beverage (F&B) conglomerates such as Charoen Pokphand Foods are investing in robots, automated production technology, and machinery to improve production standards. International players are also bringing state-of-the-art technologies into their production sites in Asia; the automotive industry of Indonesia has become an important pillar of the country’s manufacturing sector, with many of the world’s well-known car makers setting up manufacturing plants in the country. Companies are also setting up industry alliances and partnerships also help to accelerate technological breakthroughs. In Japan, companies such as Mitsubishi Electric, Hitachi, Fujitsu, NEC, Mitsubishi Heavy Industries, Kawasaki Heavy Industries, IHI, and Hitachi Zosen, members of Japan’s Robot Revolution Initiative, are collaborating to introduce products and services that enable Industrial Internet of Things (IoT).

## 2.2 Prevalence of Industry 4.0 technologies in Asian manufacturers

Manufacturers have recognized the potential benefits that Industry 4.0 technologies can deliver across the manufacturing value chain:

- **Product development.** The use of technologies such as Virtual Reality and 3D printing in product development will drastically reduce time-to-prototype and time-to-market. Product development teams would be able to experience the design virtually and also share it with other departments of the organization. Mass customization will be possible through sensors on the product which would continually monitor customer’s usage patterns.

- **Procurement and warehousing.** Companies will be able to avoid delays in supply caused due to unplanned disruptions by tracking raw materials and finished products with location sensors. Data gathered from sensors will be sent to a central analytics platform that performs simulations, generates insights and send instructions to the relevant stakeholders such as suppliers, factories and customers.
- **Manufacturing and testing.** Deployment of industrial IoT sensors would help in predictive maintenance of machines and reduce instances of delays caused due to unexpected machine breakdowns. Also, edge computing provides the speed and low latency required by robots and machines. Use of artificial intelligence powered smart glasses has the potential to eliminate use of manual checklists. Augmented Reality glasses are also very helpful to assist workers in maintenance and repair of machines by providing step-by-step instructions.
- **Order fulfilment.** A combination of artificial intelligence applications and autonomous robots could be used for managing orders received from multiple channels. Big Data analytics and cloud based central order management systems increase the visibility of inventory across locations by the real-time tracking of customers' orders.

Innovative examples of leading manufacturers adopting Industry 4.0 along the manufacturing value chain can be seen in Figure 4 below.

| Manufacturing value chain          | Manufacturing innovation     | Example of Industry 4.0 use case  | Network technology required  | Benefits   |
|------------------------------------|------------------------------|---|--|--|
| <b>Product development</b>         | 3D printing                  | <b>Product customization</b><br>Nabisco in Indonesia enhances personal experience by allowing customers to build customized Oreo cookies using 3D printing within roughly a minute  | 4G / 5G wireless communications in licensed and unlicensed spectrum (MulleFire and CBRS)<br>On-premise 4G and 5G small cells and access points | Flexibility – make things personal   |
|                                    | Automation                   | <b>Design</b><br>Leading Vietnamese apparel maker Viet Tien uses 3D design simulation workstations, digitizers, and cutters to reduce design labour by 75%  | On-premise 4G and 5G small cells and access points<br>Private cellular networks with integrated edge cloud and local gateways                  | Efficiency – Improves throughput and reduces manpower                              |
|                                    | Big Data                     | <b>Improve product efficiency</b><br>Mazda linked over 10,000 engine production data points with customer value data in 130 countries to identify value levers, resulting in engineering designs that reduced fuel variation by 25% | Cloud computing analytics  | Efficiency – better product performance  |
| <b>Procurement and warehousing</b> | Artificial intelligence (AI) | <b>Improve demand forecasting accuracy</b><br>NEC Corporation in Japan uses AI technology to improve the precision of its demand forecasting and logistics efficiency, reducing margins of error by 60%                             | IoT solution<br>Multi-access edge computing  | Flexibility – change production according to demand<br>Efficiency – reduce wastage |

|                                  |                |   |  |                           |
|----------------------------------|----------------|---|--|---------------------------|
| <b>Manufacturing and testing</b> | Smart wearable | <b>Improve operations efficiency</b><br>Sanshiba in Japan improved operations efficiency by 20% by monitoring the total time spent on each manufacturing process through a smart watch and beacon worn by factory workers   | IoT solution   | Efficiency - Productivity |
|                                  | Robotics       | <b>Workforce safety</b><br>Tatsumi Shokai Logistics in Japan uses exoskeletons to help elderly employees carry out jobs that include loading, unloading, carrying, and bending<br><br><b>Productivity</b><br>Samsung Heavy Industries' Geoje Shipyard in Korea uses autonomous robots to weld heavy pipes, increasing welding speed by 300-600%. The robots also perform automatic radiographic testing inspecting, reducing inspection time by up to 93% | Integrated high accuracy indoor positioning Multi-edge access computing. | Safety                    |

Figure 4. Innovative examples of Industry 4.0 use cases in Asia

## 2.3 Approaches adopted in Japan

Japan has a diverse, USD 158 million manufacturing sector, growing each year at 10% as of FY 2015. The automotive and electric machinery sectors are the largest, respectively accounting for 8.2% and 5.2% of the market.

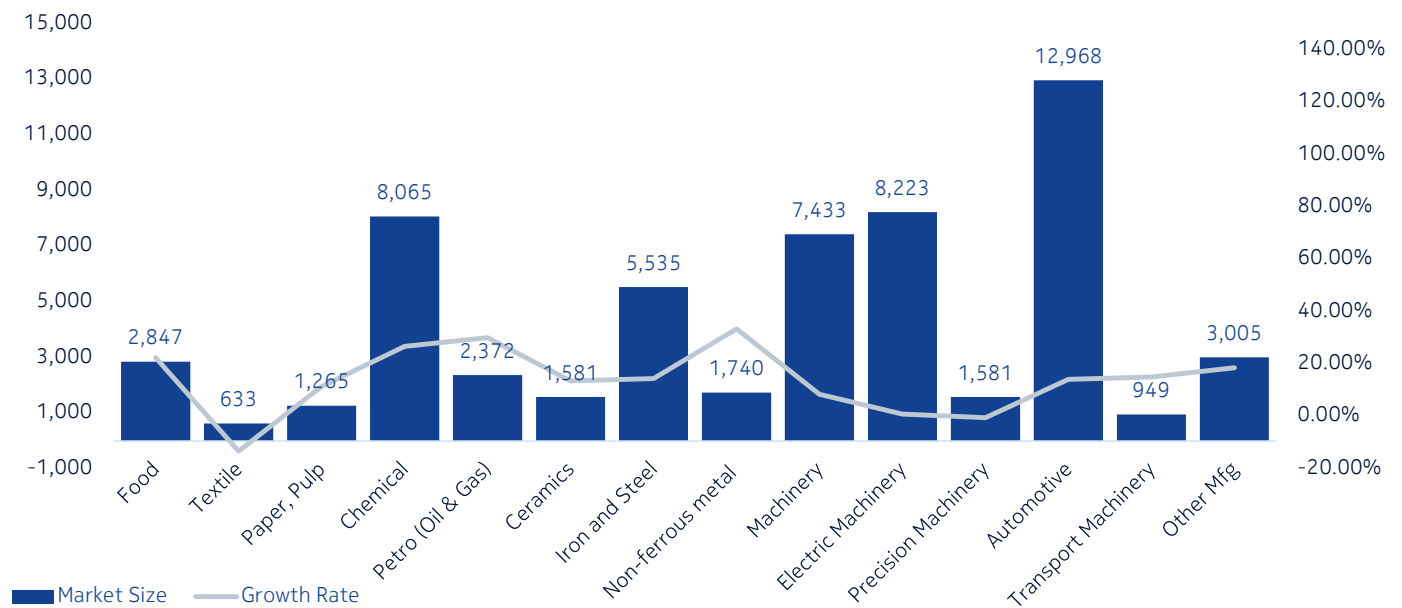


Figure 5. Market size and growth rate for capital investment in Japan's manufacturing sector



To sustain its economic growth, the Japanese manufacturing sector has conscientiously raised the level of productivity through rigorous processes, technological innovation, and workforce re-skilling. The Japanese government’s “Rebirth Strategy for Japan” aims to take advantage of Japan’s strength in manufacturing and technology, to develop USD 1.3 trillion of new industries and 4.7 million new jobs by 2020.

Japan’s global partnerships have helped pushed it to the forefront of Industry 4.0 technologies, with AI increasingly deployed in demand forecasting, advanced sensors in environment monitoring, smart wearables in workforce monitoring, and 3D printing in rapid prototyping. Today, Japan holds 50% market share of the global robot market in terms of both production and usage, and has the highest robot density in the automotive industry. Japan’s Robot Revolution Initiative is further cooperating with Industry 4.0 of the Federal Republic of Germany in 2016 on the IoT and Industry 4.0 in the fields of industrial cybersecurity, international standardization, international regulatory reform and R&D, and has already developed over 150 Industrial IoT use cases.

As there are strong OT players such as Hirata and Fanuc dominating the market, many Japanese manufacturers rely heavily on outsourced, local expertise to develop factory automation, robotic and connected sensor solutions. Other manufacturers utilize in-house system integration (SI) capabilities to converge OT/IT and develop IoT solutions. The Japanese ecosystem has increasingly built partnerships with global technology players to transform digital factories and transition towards next generation network.

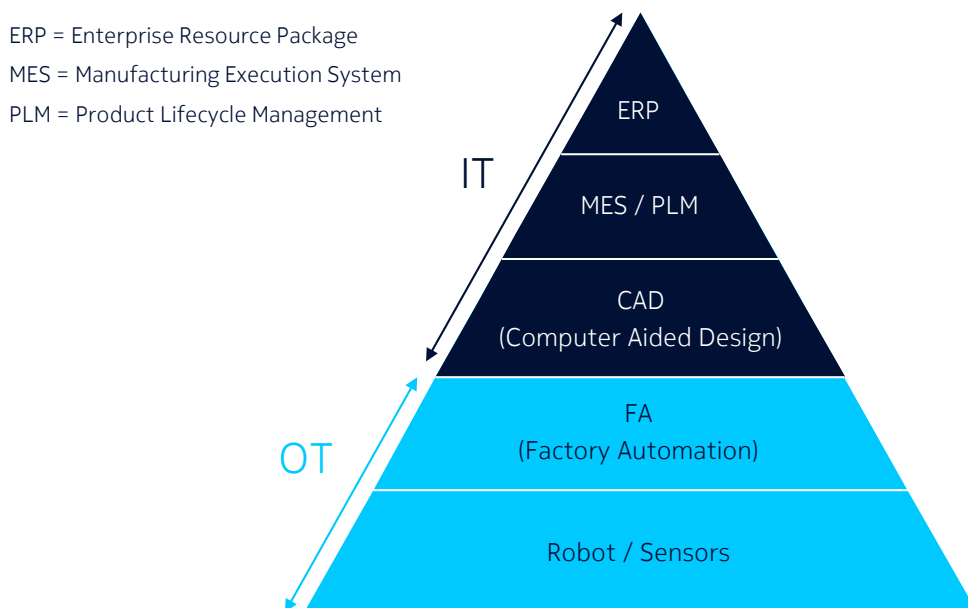


Figure 6. Convergence of IT and OT

### 3. Nokia’s Conscious Factory project

At Nokia, we have been proactively transforming our own factories into “The Conscious Factory” – an agile and intelligent manufacturing service, fully automated and green that is self-learning and able to predict demand flexibly. Our vision of a next-generation smart factory with mission-critical network is:

- To create a safe and smart environment for employees, partners, and customers
- To apply IoT to emergency services support, employee health protection, and faster response time

- To provide high-bandwidth voice, video and other data applications for mission-critical IoT services
- To connect the entire production with all enterprise related systems to get the most benefit out of it

Nokia currently uses private LTE and Wi-Fi networks to provide connectivity at its own Chennai, India, and Oulu, Finland factories. In future, cellular IoT networks such as Narrow-Band IoT (NB-IoT) could connect a wide range of low-power and low-latency devices and sensors to IoT platforms for centralized management. Figure 7 below shows the other building blocks required to piece together The Conscious Factory project.

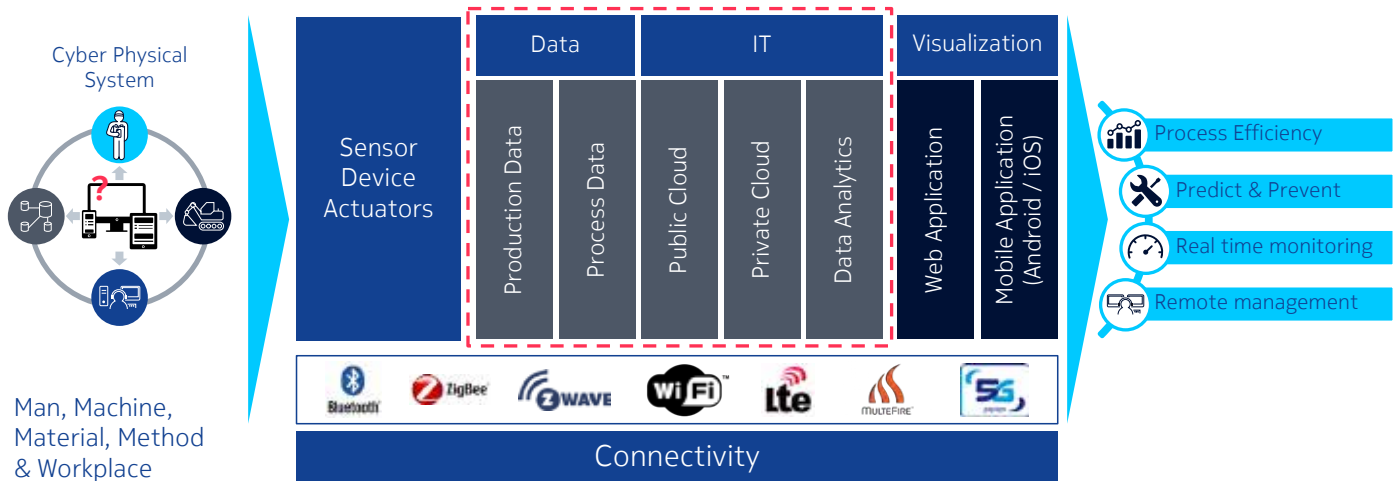


Figure 7. Building blocks for Nokia Conscious Factory

Since the implementation of The Conscious Factory project in 2015, Nokia has experienced first-hand operational efficiency and cost saving benefits.

|   |  |
|---|--|
| <h3>Procurement and warehousing</h3> <ul style="list-style-type: none"> <li>• Safe-guard workers physical well-being with automated guided vehicles (AGVs). Five AGVs follow magnetic-tape paths and move heavy materials from the warehouse to processing lines and vice versa, replacing the need for manual labour which could amount to 28km per worker per shift.</li> <li>• Optimize worker performance and safe-guard workers well-being by monitoring and managing fatigue levels. Smart cap solution sends email and mobile app alert to supervisor and workers exceeds fatigue threshold level.</li> <li>• Real-time tracking of inbound shipment of materials. Location trackers allow improved transparency of exact arrival times of shipments, thus more accurate production planning.</li> </ul> | <h3>Benefits</h3> <ul style="list-style-type: none"> <li>Improvement in Product Quality KPIs</li> <li>Overall Equipment Efficiency (OEE) improved by 13 percentage points</li> <li>Reduced time for product development and time to market</li> <li>Improved workforce utilization by 4 percentage points</li> </ul> |
| <h3>Manufacturing and testing</h3> <ul style="list-style-type: none"> <li>• Optimize production yield through environmental sensors. Condition monitoring system self-adjusts surface-mount technology (SMT) machines in line with the optimal levels of humidity in the air, resulting in lowering the failure rate of machines.</li> <li>• Optimize production yield through connected soldering machine. Legacy soldering machines are IoT-enabled to allow remote monitoring of performances to reduce defects.</li> <li>• Reduce energy consumption through automatic shut-down of equipment. Intelligent Power Off System (IPOS) shuts down testing stations in the absence of workers, resulting in overall 5% savings of energy costs across all testing stations.</li> </ul>                           |  |

Figure 8. Sample use cases implemented in Nokia Conscious Factories

## 4. Conclusion: Creating the technology to connect the world

Industry 4.0 enables a much tighter interaction of domains and among companies across the full product lifecycle, from design and manufacturing to distribution, services, and disposal. A production facility only truly becomes a Smart Factory when the full range of Industrial 4.0 technologies are meaningfully integrated. The connected workers, product designers, and end users will interact with the physical equipment and products, as well as with digital twins of the same equipment and with the digital data and intelligence about the past, current, and future predicted behavior of the products. They will draw information from sophisticated analytics tools to improve the overall efficiency of the value chain and create new value-added services through automation, process simplification and knowledge sharing. In addition also distributed processing capabilities, especially at the edge of the network support real time data processing where the gained information can be implemented right away in the production process to smoothen the same even more and gain efficiency. The potential global economic impact is expected to go beyond EUR 1 trillion by 2025 for factory applications<sup>18</sup>.

The network that connects various platforms therefore needs to be rigorous enough and consist of the following key building blocks to deliver manufacturing innovation to drive Industry 4.0:

- Industry-leading 4G and 5G wireless communications in licensed and unlicensed spectrum
- On-premise 4G and 5G small cells and access points
- Private cellular networks with integrated edge cloud and local gateways
- IoT PaaS (platform as a service) with IoT device and connectivity management solutions and analytics applications
- Integrated high accuracy indoor positioning
- SIM-less IoT authentication methods and embedded security
- Interfaces/APIs to local applications
- E2E industrial slice and quality of service over public infrastructure
- Real-time remote control and augmented reality
- Ecosystem trials with Nokia Innovation Platform

Many innovative technologies already exist today or are being developed in areas such as Industrial IoT , augmented, collaborative and swarm robots, autonomous vehicles, augmented, virtual and mixed realities, artificial intelligence, machine learning, predictive maintenance, smart products and connected workers. Applications are being developed, tested, and deployed at an ever-increasing pace to support new use cases and services. All these innovations require a multi-disciplinary approach with a deep industrial understanding. To achieve the highest degree of information sharing and knowledge extraction, all devices, machines, sensors and people need to be connected through a real-time, reliable, secure, high-performance and programmable platform.

Nokia is ideally placed to deliver this fabric of advanced connectivity and cloud infrastructure – which we call the digital nervous system – for the connected industries and digital automation of the future.



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