

The Principal, Practices and Current Challenges of Industry 4.0 Technologies



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November 22

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Introduction

This short report (1500-word limit) discusses the principles of Industry 4.0 and the current challenges that must be overcome for it to be widely adopted. Industry 4.0 is an important development area for the UK – highlighted within the following pivotal UK Government strategy documents for industry:

- **Industrial Strategy** (HM_Government, Industrial Strategy 'Building a Britain fit for the future', 2017) - sets one of its 'grand ambitions' as putting the UK at the forefront of the 'Artificial Intelligence and Data' revolution.
- **Innovation Strategy** (BEIS, 2021) - lists 'Artificial Intelligence, Digital and Advanced Computing' and 'Robotics and Smart Machines' as two of seven technology families of UK strength and opportunity that will be supported.
- **Decarbonisation Strategy** (HM_Government, 2021) – highlights the disruptive potential of Artificial Intelligence for reducing energy usage and carbon emissions. Other Industry 4.0 technologies such as 3D Printing and Digital Twins are also highlighted as potentially important to help maximise efficiency improvements.

Clearly business adoption of Industry 4.0 technology is of significant national importance.

The Principles of Industry 4.0

The term 'Industry 4.0' is thought to originate from Germany in 2011 and marks the dawn of the 4th Industrial Revolution (the first was machinery driven by steam in the 18th century, the second marked the dawn of electrification in the 19th century, the third marked the start of the digital era through the introduction of computers in the 1970's). The fourth industrial revolution celebrates the connection of physical assets to digital technologies that has been enabled more broadly through the introduction of cloud-based data storage and computing to process the enormous amounts of data that a smart factory would produce (it is estimated that a smart factory could produce 5 million gigabytes of data per week) - although data can often be processed at the network 'edge' (edge computing) to reduce latency and energy use. Some of the connected technology that sits under the Industry 4.0 umbrella is shown in Figure 1.

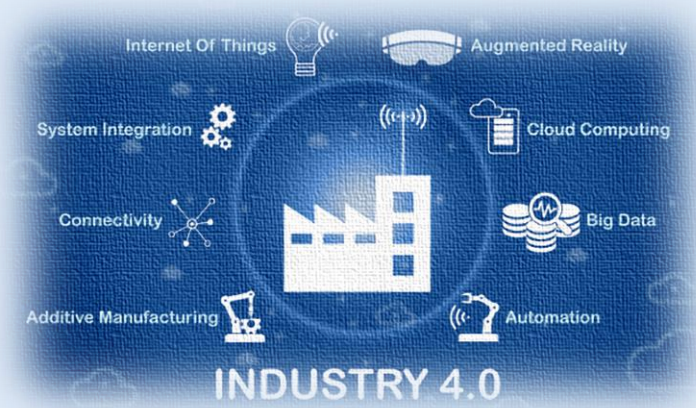


Figure 1 – Technologies that sit under the Industry 4.0 umbrella

Industry 4.0 technology facilitates the creation of intelligent factories and supply chains where productivity, sustainability and business resilience are optimised. This is achieved by incorporating IIoT (Industrial Internet of Things) for the true and real time integration of production systems and the people that engage with them (Gilchrist, 2016). Intelligent and autonomous manufacturing that is connected through the internet with very little human interference is no longer confined to the works of science fiction.

Manufacturing and process data collected via Distributed Control Systems (DCS), Programmable Logic Controllers (PLC) and Supervisory Control & Data Acquisition (SCADA) can be harnessed under an overarching Manufacturing Execution System (MES) that has 11 core functions such as Quality Management, Resource Allocation, Product Tracking, Process Management etc. (see Figure 2) (Ghobakhloo, 2018).

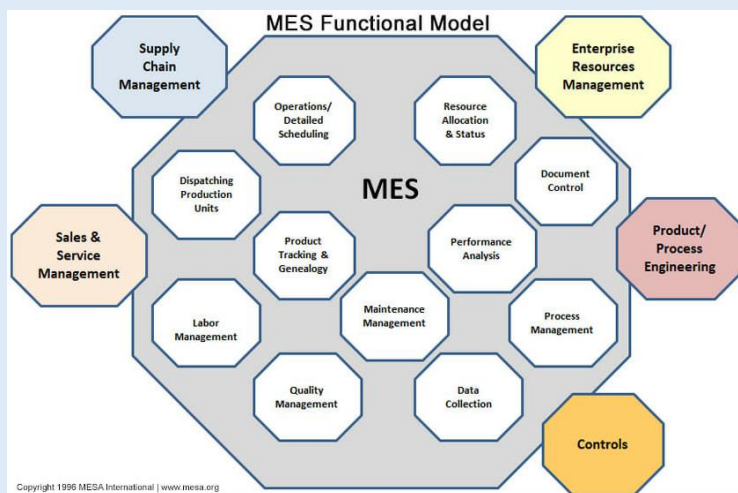


Figure 2 – The 11 core functions of a MES system

A layer above the MES system, at the top of the hierarchy of connectivity, sits the Enterprise Resource Planning (ERP) system (see Figure 3).

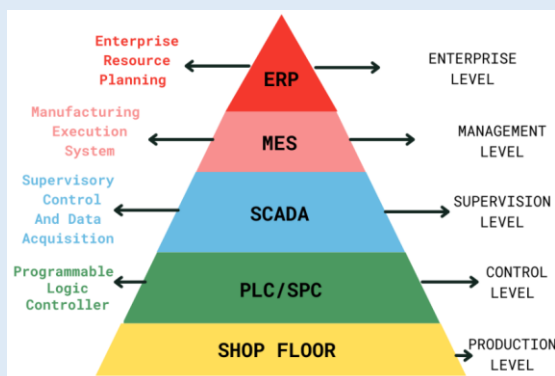


Figure 3 – Hierarchy of Connectivity

ERP creates the comprehensive information system that integrates all elements of the business. If the ERP system is coupled with Discrete Event Simulation (DES) tools and Artificial Intelligence/Machine Learning then Digital Twin (DT) models can be created that provide a real-time digital model of the entire manufacturing system (Coronado, 2018). The use of DES software to create a digital simulation that is converted into a Digital Twin is discussed in the next chapter.

The Challenges for Industry 4.0

Supply Chain Integration

The factories of the future will involve highly complex and customised models that require the integration and alignment of the entire supply chain for dynamic manufacturing (Frank, 2019). This introduces technical challenges that might be obvious such as scale, complexity and security. However, it also introduces many new softer challenges such as the levels of acceptable transparency to each stakeholder, accountability for data accuracy and IP rights (Castelo-Branco, 2019).

Some of these softer barriers can be broken though the adoption of blockchain technology and the Web of Things (WoT) to ensure data consistency across different supply chain platforms and protecting partner IP (Li, 2018). This would help to streamline the flow of goods, records and receipts, tracking, financial transactions and possibly knowledge transfer across the whole value chain (Saqlain, 2019).

Collecting the Right Data & Defining the System

Before implementing Industry 4.0 technology, it is first important to understand the business operating model and its challenges. This involves discussion with all of the internal stakeholders – owners, managers, operators, maintenance teams etc. Siemens use a 3 Gate ‘feasibility and scope’ process for Industry 4.0 implementation (see Figure 4). Gate 1 involves engagement with the business staff, defining goals, data dictionaries, process maps, system boundaries and boundary diagrams. Once Gate 1 is signed off by the internal stakeholders of the business, Gate 2 involves designing the architecture, connectivity models. Gate 3 involves staff training, implementation and early life support.

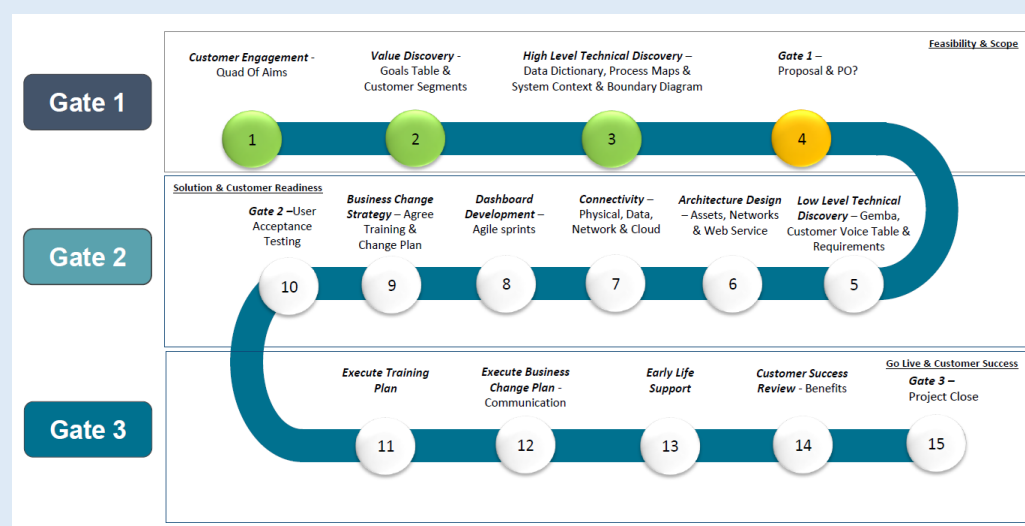


Figure 4 – Gated Process for Feasibility & Scope Definition

Discrete Event Simulations and Digital Twins

Discrete Event Simulation software has been used for decades to create a digital model of manufacturing lines to identify bottlenecks by simulating the flow of product through the different machinery and internal logistics (see Figure 5). Capacity of the line can be optimised through an iterative process of identifying the bottleneck, redesigning the layout to break the constraint, then re-running the simulation to identify the new improved line capacity and the new bottleneck. The whole cycle can then be repeated.



Figure 5 – Siemens Discrete Event Simulation Software (Plant Sim)

With the recent explosion of IIoT devices, there is now an exciting potential for DES models to become cyber twins of the physical lines. Real time data from the IIoT devices on machinery can be fed to the DES model for the execution of queries that support better planning, management and decision making.

Work to create Digital Twins from DES models is in its infancy, but when coupled with AI and ML, the opportunities for improving business performance are significant. This is an important area for technology development (McKinsey&Company, 2017).

A Fear of the Unknown (New Technology)

According to Forbes, almost 50% of employees suffer from some level of anxiety and fear when new technology projects are announced by businesses. It is therefore crucial that organisations support their staff to demystify new advanced technologies – failure to do so could result in the unsuccessful implementation and adoption of Industry 4.0 (Sweis, 2022). Explaining the objectives of the technology implementation to all levels of the business and giving freedom to staff to explore creative uses of the new tools are examples of ways in which staff can feel involved and empowered.

Skills

There should be no doubt that Industry 4.0 technology will replace some jobs - it is estimated that there are already over 50 million service robots and 3 million industrial robots operating globally (International_Federation_Robotics, 2018). Whilst only a small percentage of jobs can be fully automated, some activities of almost all jobs can be automated (McKinsey&Company, 2017). There are two challenges facing business leaders in terms of staff skills. Firstly, a large number of staff will

require reskilling to take on completely new roles that involve new technology. Secondly, some staff will need upskilling to carry out elements of their existing role in new ways using new technology. Either way, this requires investment in both off the job and on the job training – to create the workforce of the future.

Conclusion

Industry 4.0 technologies will help businesses to be more productive, sustainable and resilient. The UK has suffered a number of recent economic shocks (Covid, Brexit etc.) and most economists fear that the country is entering a period of recession that will last for 2 years. There should be no delay to the adoption of Industry 4.0 by UK manufacturing sectors – however, the reskilling and upskilling of staff is crucial to success.

WORD COUNT - 1568

References

- BEIS. (2021). *UK Innovation Strategy 'Leading the future by creating it'*. London: UK GOV.
- Castelo-Branco, I. (2019). Assessing Industry 4.0 Readiness in Manufacturing: Evidence for the European. *Comput.Ind*, 22-32.
- Coronado, P. D. (2018). *Part Data Integration in the Shop Floor Digital Twin: Mobile and Cloud*. Atlanta: Georgia Institute of Technology.
- Frank, A. G. (2019). Industry 4.0 Technologies: Implementation Patterns in Manufacturing Companies. *Int.J.Prod.Econ*, 15-26.
- Ghobakhloo, M. (2018). The future of manufacturing industry: a strategic roadmap toward Industry 4.0. *Manufacturing Technology Management*, 910-936.
- Gilchrist, A. (2016). *Industry 4.0*. New York: Apress.
- HM_Government. (2017). *Industrial Strategy 'Building a Britain fit for the future'*. London: UK GOV.
- HM_Government. (2021). *Industrial Decarbonisation Strategy*. London: UK GOV.
- International_Federation_Robotics. (2018). *Robots and the Workplace of the Future*. Frankfurt: IFR.
- Li, Z. (2018). Toward a Blockchain Cloud Manufacturing System as a Peer to Peer Distributed Network. *Robot.Comput.Integr.Manuf*, 133-144.
- McKinsey&Company. (2017). *A Future that Works: Automation, Employment and Productivity*. San Francisco: McKinsey.
- Saqlain, M. (2019). Framework of an IoT-Based Industrial Data Management for Smart Manufacturing. *J.Sens.Actuator*, 25.
- Sweis, D. (2022, August 24). *Demystifying Automation: Inspire Your Team To Embrace New Technology, Not Fear It*. Retrieved from Forbes: <https://www.forbes.com/sites/forbestechcouncil/2022/08/24/demystifying-automation-inspire-your-team-to-embrace-new-technology-not-fear-it/?sh=23238e3d4e9c>

