

Industry 4.0 Opportunities within a Welsh Aircraft Seat Manufacturer

Advanced Manufacturing Assignment 2 – Essay

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1. Introduction

This paper focuses on an aircraft seat manufacturer in South Wales, specialising in the manufacture of First and Business Class suites. In the current challenging economic climate, the company recognises that they must do things differently if they are to remain ahead of the competition within a fiercely competitive market.

One of the key manufacturing systems within the business is that of the final assembly line (FAL). At the FAL, seat assembly takes place over a number of different stages, with each stage manned by its own operator. Once an operator has completed his operation, the assembly will ‘Flow’ to the next operation until all operations are complete and the seat is fully assembled, this is referred to as a ‘Flow Line’.

With Industry 4.0 upon us, the company realises there may be potential in the fourth industrial revolution that can be applied to ensure they strengthen their position in the seat manufacturing market. However, Industry 4.0 has only recently become a regular topic within the company and there is still much to understand on how (in practice) Industry 4.0 fits into the business and predominantly within the manufacturing systems such as the FAL.

This paper will look to Industry 4.0 to understand the technologies that this new revolution has on offer and to answer the research question:

‘How can a Welsh aircraft seat manufacturer benefit from Industry 4.0 key enabling technologies and what implications and/or factors must be considered in adoption of such technologies?’.

In section 2, the Industry 4.0 concept and the key enabling technologies that fall within this umbrella are discussed further. While section 3 draws focus on the key factors involved when adopting Industry 4.0 technologies within a manufacturing organisation. Finally, in section 4 a conclusion will be drawn to determine if the aforementioned research question has been answered.

2. Industry 4.0

Industry 4.0, also referred to as ‘The Fourth Industrial Revolution’ is considered to be the change in industry from traditional manufacturing to smart manufacturing through the use of enabling technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), Cyber-Physical Systems (CPS), robotics and Big Data (Pereira & Sachidananda, 2021).

In 2011, the term ‘Industry 4.0’ was first used at the Hannover Fair in Germany to describe a project involving the government, academia and the private sector. The project objective was to strengthen Germany’s competitiveness in global manufacturing (Kang, 2016). Many other countries have since followed suit, for example in the USA, the ‘Advanced Manufacturing Partnership’ was launched, ‘Smart Factory’ (UK), and the Chinese initiated the ‘Made in China 2025’ project (Kumar & Mathiyazhagan, 2020).

Within the current literature, there are more than one hundred different definitions of the term ‘Industry 4.0’ according to Moeuf (2018). One definition is that Industry 4.0 is an advanced

model within manufacturing that consists of (within itself) an extensive set of technologies not necessarily unpublished but integrated with each other and the industry as a whole which is characterised by its high digital, virtual and technological performance (Carvalho & Cazarini, 2019). Schwab (2017) defines Industry 4.0 as the movement towards automation within manufacturing and ultimately increasing efficiency by creating ‘smart factories’, where it can be regarded as the integration between production processes and the internet of things, through the use of sensors and artificial intelligence applied to machines.

Industry 4.0 is still a relatively new industrial model that comes with disruptive characteristics in relation to environmental performance as it is also considered a sustainable manufacturing model. It also offers a set of potential technologies that can eliminate the more intense physical work performed by workers within the industry (Carvalho & Cazarini, 2019). On the contrary, Carvalho & Cazarini (2019) also state that Industry 4.0 is not just a technical challenge but also a movement that will change the organisational structure within a company significantly.

2.1. Industry 4.0 Enabling Technologies

Technologies that bear high transformative potential within a productive system that they are deployed in can be defined as ‘enabling’ (Teece, 2018).

According to Franka, et al., (2019), Industry 4.0 technologies can be divided, at least, into two different categories; ‘Front-end Technologies’ and ‘Base Technologies’. Figure 1 shows this framework in more detail.

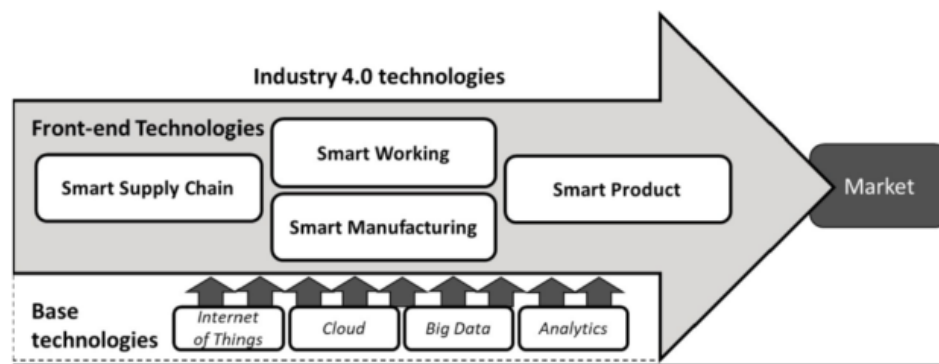


Figure 1: Theoretical Framework of Industry 4.0 Technologies (Franka, et al., 2019)

At the centre of the framework is the Front-end technologies of Industry 4.0, which considers the transformation of the manufacturing activities based on emerging technologies (Smart Manufacturing) and the way products are offered to customers (Smart Products) (Dalenogare, et al., 2018). The framework also considers how products and raw materials are delivered (Smart Supply Chain) and the new ways in which employees are able to perform their duties using Industry 4.0 emerging technologies (Smart Working) (Franka, et al., 2019).

These four technologies (smart supply chain, smart working, smart manufacturing and smart product) are referred to as front-end technologies as the four ‘smart’ dimensions are interconnected with operational and market needs and therefore have an “end application

purpose” for the organisations value chain, this is represented by the arrow from left to right in figure 1.

This layer of ‘Front-end’ technologies is heavily reliant on another layer referred to as ‘base technologies’. The base technologies consists of the Internet of Things (IoT), Cloud computing, Big Data and Analytics and provide the foundation for the front-end layer; providing the essential connectivity and intelligence for front-end technologies to be able to operate. They are considered base technologies, as they are present in all dimensions and different technologies in such dimensions that enable the Industry 4.0 concept, differentiating the fourth industrial revolution from its predecessors as base-technologies enable front-end technologies to be interconnected in a complete integrated manufacturing system (Wang, et al., 2016).

As the study company is still yet to adopt any of the base technologies (IIoT, Cloud Computing and Big Data / Analytics) discussed, the next section will research these technologies further to understand what they can offer and to the aircraft seat manufacturer prior to adopting front-end technologies within Industry 4.0.

2.1.1. Industrial Internet of Things (IIoT)

The Industrial Internet of Things (IIoT) is a disruptive technology development that has taken industry by storm. Driven by industrial demand, technological developments, and government initiatives, IIoT has been widely adopted in the manufacturing sector, where it has seen the most investment exposure (Ramakrishnan & Loveleen, 2019).

The Internet Engineering Task Force (2009) define the IIoT as a system to connect to the objects around us, whether they are electrical, electronic or non-electrical. This enables seamless communication and contextual services provided by them. Development of sensors, RFID tags, actuators and smart devices (tablets/phones) make it possible to materialise the IIoT, interacting and co-operating with machines that are accessible from anywhere at any time. Furthermore, the IIoT technologies minimise downtime, accelerate productivity and make safer working conditions for employees, thus providing a competitive edge for manufacturing companies. However, there are challenges to consider when adopting the IIoT within an organisation, such as technological feasibilities, security, privacy, user acceptance, and financial constraints that could affect the adoption and must be taken seriously (Ramakrishnan & Loveleen, 2019).

2.1.2. Cloud Computing

Twenty years ago, the cost of storing 1GB of data was more than \$10,000 USD. Storing the same 1GB of data in 2016 cost less than \$0.03 a year. Accelerated by Amazon’s web services in the early 2000’s, elastic computing has made access to powerful computing resources easier. Small organisations can now hire computing power by the second. Combining significant process power with low-cost storage is a key enabler than just for the previously discussed big data; it also offers a foundation for deploying other Industry 4.0 technologies, such as the IoT, augmented reality, robotics etc.

Companies of all sizes can expect to see significant benefits by adopting cloud-computing resources. In addition to its scalability, cloud computing can be resilient to both malicious external activities and system technical failures, more so if the cloud based services are provided by external specialist companies rather than that of an internal IT department. Seeking external support will not remove the need for cyber resilience internally but it will go a long way to reducing the risk of security breaches and data loss. Using an external provider and storing data and applications remotely rather than within company premises can also cut IT costs significantly and speed up operations (Wall, 2016).

For multi-site manufacturing companies and those that have complex supply chains, the cloud can cumulate and act upon data from anywhere in the world in real time. However, there are risks that must be carefully considered, specifically that of data privacy, as the company would effectively be giving up control of their data to someone else to take care of. Therefore, it is essential to conduct extensive research prior to choosing a cloud provider for your business; ensuring potential providers meet all the necessary requirements and expectations the company has.

2.1.3. Big Data and Analytics

Big Data refers to methods and tools that process large volumes of data for manufacturing, supply chain management and maintenance. Data can be extracted from anywhere within the factory through the IoT systems that are connected to the productive layer via sensors and associated equipment. The way in which large amounts of data can be extracted and stored is becoming easier and cheaper, driven by low cost sensors and microprocessors that can be built in or attached to manufacturing equipment. The plug-and-play nature of these in-situ devices enables continuous monitoring of a manufacturing system where previously, sample inspections carried out by an operator would have been the norm.

Using such sensors to gather this data can also reduce process variation by identifying potential errors early on, leading to better Overall Equipment Effectiveness (OEE), less defects and less scrap. However, to achieve this, the data must be converted into information that can enable managers to make informed decisions. This will often require new data science skills and training, and this can become a significant barrier in achieving its full benefits.

From a humanistic and environmental viewpoint, such insights can bring significant benefits with little if any downsides; a more productive company is generally a more profitable company. A more profitable company is likely to invest more in staff well-being and skills. A company that can produce with little scrap will consume less raw materials and will have a lighter carbon footprint. Adoption of big data can have potential downsides, for example, less staff may be required in certain roles as manufacturing systems become more automated and efficient. However, Schwab (2017) acknowledges that there will be a need for new job categories to be created as a result.

3. Industry 4.0 Adoption

The numerous benefits and challenges associated with Industry 4.0 adoption have been widely discussed in recent literature. The potential benefits and challenges can vary depending on location, organisation size, and implementation strategy. Oesterreich and Teuteberg (2016) identify key benefits and challenges associated with industry 4.0 adoption through global systematic literature reviews: Benefits: Quality, efficiency, and productivity have all improved. Cost savings, improved communication and collaboration from top to bottom, better customer relations, and increased safety. Workforce acceptance, employee competency, high adoption costs, lack of funding, process changes, lack of standards, outdated computers/networks, legal (cyber security / data protection and regulatory compliance), contractual uncertainty are some of the key challenges associated with Industry 4.0 adoption.

Understanding the potential benefits and challenges of industry 4.0 adoption is critical for an organisation if it is to be successful in delivering the change. However, it is equally important to understand what industry 4.0 means outside of the organisation (looking at the big picture), which extends beyond the industrial sector, in order to understand what some of the wider implications of adopting industry 4.0 ideologies within organisations are. .

3.1. Economic Factors

Industry 4.0 is expected to have a significant impact on all industries and the global economy (Kumar, 2022), as industries and governments around the world realise the true potential of industry 4.0 and how it is transforming economies for the better.

SMEs play a significant role in this; in the EU (European Union), 90% of businesses are SMEs (Masood & Sonntag, 2020). As a result, it is in everyone's best interest for SMEs to be supported (financially and/or strategically) in order to increase their innovation capacity. For example, the European Commission (EC), which is funded by the EU, assists organisations in conducting research and innovation projects (European Parliament, 2015).

3.2. Humanistic / Social Factors

Industry 4.0 adoption will have a significant impact on the workforce. Because of the buzz surrounding Industry 4.0, the latest industrial revolution has left many employees feeling insecure about their jobs as they witness robots performing tasks that were previously performed by them. This makes people anxious as they try to figure out where they fit in within the modern smart factory, and can result in a demotivated and disengaged workforce. To counteract this, organisations must foster an engagement culture.

An engaged workforce is 38% more likely to be productive (Hearn, 2020). Furthermore, the adoption of Industry 4.0 will necessitate a significant shift in recruitment, skills, and training to ensure the transition is successful. Human resources departments will play an important role in this because they will need to understand what future skills are required (Gates & Bremicker, 2017). Current employees may also need to be upskilled, and/or new skilled workers may need to be recruited. In addition, new processes and procedures will need to be developed in

preparation for the implementation of Industry 4.0. Additionally, new processes/procedures will need to be developed in preparation for implementing industry 4.0.

3.3. Environmental Factors

The global manufacturing sector is responsible for a vast carbon footprint. In France alone, the sector is responsible for 17.8% of all greenhouse gases and is a mass producer of waste and pollution.

With so much emphasis on the effects of climate change, it is no surprise that there is a lot of interest in sustainable innovation. The French government launched a low-carbon strategy in 2020 with the goal of developing disruptive technologies capable of lowering the country's carbon footprint (Pollutec, 2020). Although there are many debates about whether Industry 4.0 will actually improve industry's environmental impact, considering the amount of raw materials required to produce such vast amounts of digital technology moving forward, only time will tell.

While the environmental impacts of future digital technology manufacturing are yet to be determined, there are numerous examples of existing industry 4.0 technology having a positive impact. For example, leading engine manufacturers Safran and GE aviation have designated 3D printing as an industry 4.0 environmental innovation due to its use in aircraft engines. Metal 3D printing has resulted in weight reductions of one-quarter, lowering costs for both manufacturers and airlines while also reducing environmental impact (Sertoglu, 2022).

3.4. Security

Industry 4.0 has the potential to significantly alter and improve people's lives. However, as with all new technologies, it introduces new challenges, forcing surrounding industries to adapt. One of the most hotly debated topics in industry 4.0 is security, and the importance of having reliable security in place prior to storing and moving data across the cloud. With cyber-security threats evolving all the time and cloud-based platforms becoming the go-to for everyone from individuals to large corporations, hackers are turning to cause damage to businesses, steal data, and corrupt systems (Taylored Systems, 2020).

As a result, regardless of industry or size, organizations moving to cloud computing must prioritize security vulnerabilities unique to cloud-based platforms, such as data protection, employee access, hacker effects on AI-based systems, and more.

4. Conclusion

In the introduction, the research question that this paper set out to answer was ‘How can a Welsh aircraft seat manufacturer benefit from Industry 4.0 key enabling technologies and what implications and/or factors must be considered in adoption of such technologies?’.

Within the literature surrounding Industry 4.0, a small number of key enabling technologies identified as Industry 4.0 ‘base technologies’; the Industrial Internet of Things (IIoT), Cloud Computing and Big Data/Analytics. These technologies are seen as the foundation of any successful Industry 4.0 adoption and must be integrated into any manufacturing organisation prior to moving into next phase whereby ‘front-end technologies’ are introduced.

The four technologies mentioned each have unique capabilities. The IIoT aims to solve communication issues among all objects and systems in a factory, whereas cloud services enable easy access to information and services. Finally, big data and analytics are regarded as key enablers of advanced Industry 4.0 applications, because the intelligence of the system is dependent on the large amount of data accumulated (big data) and the ability to analyse with advanced techniques (analytics).

Researching each base technology further, it was evident that there are significant benefits that each can offer. For example, introducing the cloud within an organisation will provide significant productivity insight to what is happening within the business. With the use of sensors installed into a IIoT platform it is now possible to monitor machines in real-time, providing data constantly that can help identify where the weak/problem areas are within the assembly line and ultimately increasing efficiency, quality and cost. This is made possible by the power of the cloud, delivering information and performance data that enables an organisation to make adjustments prior to an issue even arising, resulting in less downtime and costs. With the many benefits Industry 4.0 technologies can bring, there are key factors (humanistic, economic, environmental and security) that need to be carefully considered when adopting such technology. However, by adopting a plan and strategy well in advance of adoption can ensure that the benefits outweigh any risks and once the base technologies are fully integrated as part of a carefully orchestrated strategy, front-end technologies can then be considered.

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