

# **Aircraft Seating**

## **New Product Development & Digital Twin**

### **Industry 4.0**

### **Advanced Manufacturing**

### **Assignment 1 – Written Report**

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## 1. Summary

In the era of industry 4.0, there are many emerging technologies such as cloud computing, Artificial Intelligence (AI) and the Internet of Things (IoT) that are becoming essential tools within organisations throughout the world. Among these technologies, is 'Digital Twin', a technology that is becoming widely used within many industries, especially manufacturing where the technology can monitor performance, optimise progresses, predict potential errors and provide solutions (Lo, et al., 2021).

This report considers the implementation of digital twin within an aircraft seat manufacturer based in South Wales that design and manufacture Business Class and First Class seats for customers across the globe. The organisations business model is evolving, driven by the advancements in technology that is changing the game amongst its competitors as they battle to get their products to market the quickest while also delivering more reliable and safer seats to their customers.

The focus of the report is directed to the organisations 'Product Development Process' and how digital twin can provide an effective solution for product design in the future and what value and impact this may have within the organisation. Additionally, the report considers an implementation strategy for such technology as digital twin.

## 2. Introduction

Product development is the process of converting an idea or market opportunity into a complete functioning product for an end-user (Lesuer, 2022). Globalisation and an increase in customised demands has resulted in a progressively smaller time window for product development. Therefore, to ensure organisations remain competitive and stay ahead of the curve, they must respond to these market fluctuations rapidly (Rosenau, 1998).

The three key stages at the heart of any product development are design, validation and manufacturing (Rosenau, 1998) with each stage playing a vital role, where failure to plan and execute either one effectively can mean the difference between product failure and product success. According to Huang, et al., (2021), the validation stage is the key part in this process in ensuring the product development is successful. Sitting between the design and manufacturing stages, the validation stage provides an opportunity to identify potential errors and assess the feasibility of the design prior to manufacturing (Huang, et al., 2021).

With the arrival of industry 4.0 and the developments made in IT and advanced manufacturing technologies, digitalisation within product development is accelerating (Lu, et al., 2020). Traditionally, product validation has been completed using only physical prototypes, whereby engineers evaluate performance and feasibility of a design physically, referred to as physical validation. The physical process can be extremely costly, as it requires a physical manufacturing system to create prototypes. As issues and modifications occur the number of prototype's increases, as does the cost and resources needed to complete the product validation.

The aim of this report is to demonstrate the potential of an emerging Industry 4.0 technology, that is digital twin, and to determine what it can offer to an aircraft seat manufacturer based in South Wales in regards to their product development process. The company's objective is to improve the efficiency of the process and overall performance and safety of seats while in service.

### 3. Aircraft Seat Manufacturer – Product Development Current State

The chosen company, an aircraft seat manufacturer in South Wales, design and manufacture first and business class seats and components for airlines throughout the world. The company remains heavily reliant on traditional product development methods that have remain unchanged in the company for over 25 years. With competition in the seat market growing fiercer and competitors pushing to get their latest product to market faster, the organisation cannot stand still.

The existing process consists of seven steps; concept, design, physical prototype, testing, change of design and setting up operation, the process flow is shown in figure 1.

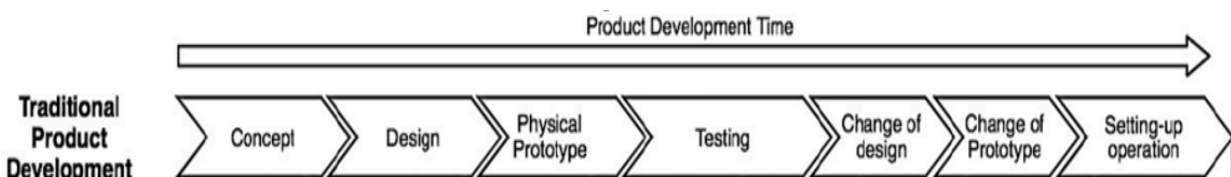


Figure.1 Traditional Product Development Process used within the Aircraft Seat Manufacturer (Lo, et al., 2021)

The existing process is inefficient and with deadlines being so tight, the company often struggles to deliver the final product to the customer on time. The biggest contributor to this is the time taken to manufacture physical prototypes and conduct physical validation. Any issues that arise at the validation stage takes additional time and resources to correct. Applying an industry 4.0 technology such as digital twin prior to the production of the physical prototype can allow these issues to be foreseen at an earlier opportunity.

## 4. Digital Twin

The digital twin concept has been part of Product Lifecycle Management (PLM) for almost twenty years and definitions of digital twin have evolved over time (Grieves, 2007). Madni et al. (2019) define a digital twin as a virtual representation of a physical system that is constantly updated with performance, maintenance, and health status data throughout the physical system's lifecycle.

The digital twin, also referred to as a device shadow, mirrored system or a synchronised virtual prototype has become a significant and emerging trend in many applications, transforming the design and operation of intelligent physical systems (Rasheed, et al., 2020). For example, in the aerospace industry, digital twin is growing increasingly popular with aircraft manufacturers and its suppliers. Airbus are using digital twin as a life management and certification paradigm, where simulations and models are used to experience real life conditions and environments to enable high-fidelity modelling of aircraft throughout their service lives (Tao, et al., 2018).

In its simplest form, MJV (2020) states that digital twins analyse, monitor and improve its physical counterpart, made possible by sensors within the physical object that are constantly collecting data which is processed and mapped onto the virtual model (digital twin). Intelligent software and smart algorithms analyse the data and provide crucial information about the physical item, helping users to understand the present and predict the future.

For a digital twin to function effectively, it should meet three requirements:

- 1). be identical in appearance as the physical asset
- 2). behave in the same manner as the physical asset
- 3). capable of analysing data to determine the pros and cons of the physical object, while predicting problems and suggesting solutions.

(MJV, 2020)

## 5. Types of Digital Twins

Digital twin technology is growing increasing in popularity throughout different industries and vary in terms of size, requirements and cost. Although they are usually divided into three category types; Product Twins, Process Twins and System Twins.

### 5.1. Product twins

Manufacturers use a virtual prototype of a product before setting up a production line to analyse how it will perform under various conditions and what problems may arise.

This gives organisations the ability to make necessary changes and create a more efficient design. As a result, the digital twin of the product helps to reduce production costs and time-to-market while improving quality.

### 5.2. Process twins

These types of models are used to simulate manufacturing processes. A virtual manufacturing process can generate various scenarios and demonstrate what will occur if it were to happen in the physical world. This enables a business to devise the most efficient production methodology while performing predictive maintenance to avoid costly downtime.

### 5.3. System twins

System twins are defined as virtual models of any type of system. They collect large amounts of data to help create new opportunities for process optimisation (MJV, 2020).

## 6. Aircraft Seat Manufacturer – Product Development Future State (Digital Twin Assisted)

The proposed solution to improve the efficiency of the company's product development process is to apply digital twin technology. Digital twin has the capability to improve and speed up each step of the process as identified by Lo, et al., (2021) in figure 2.

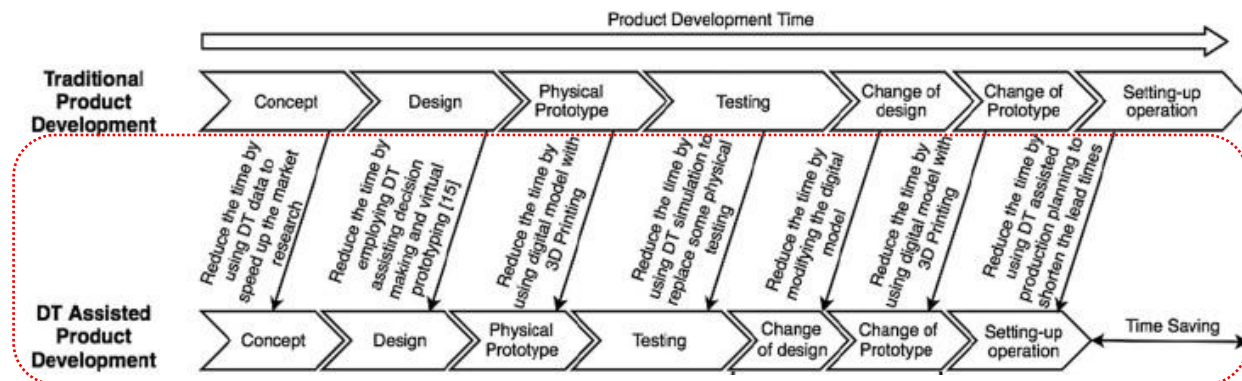


Figure 2 – Proposed Digital Twin (DT) Assisted Product Development Process (Lo, et al., 2021)

Within the first step in the development process ‘Concept’, digital twin can reduce time by using historical data to speed up market research. During the design stage, digital twin has the capability to reduce time taken by ‘assisting designers with decision making and virtual prototyping’ (Lo, et al., 2021). The next stage physical prototyping can be improved by using digital models alongside 3D printing. At the ‘Testing’ stage, the chosen company has a relatively small test department and little resource, applying digital twin simulation will allow engineers to conduct a number of tests virtually and reduce the amount of physical testing, easing the workload for the test department which has become a bottleneck in the process.

If a design change is required after the testing stage, any modifications can be applied to the digital model and a change to the prototype can be carried out using the digital model and 3D printing. The efficiency of the final stage in the process ‘Setting-up operation’ can be improved by using digital twin assisted production planning that has the capability of shortening lead times (Lo, et al., 2021).

Using a digital twin to assist product development process has the potential to improve the efficiency of the existing process at every stage. With the company struggling to hit deadlines and with limited resources, a different approach is needed. Digital twin has the capability to ensure the company's products reach the market prior to its competitors, which is a significant selling point to the world's airlines.

## **7. Digital Twin Implementation**

According to Imielski (2022), digital twin adoption often fails to deliver on the business stakeholders' expectations. The reasons for this does not lie in the limitations of the technology itself, but in the lack of organisational readiness and a poor implementation process.

To ensure a successful implementation of digital twin, Imielski (2022) identifies six best practices that can be applied by the chosen company to achieve the desired results.

### **7.1. Preparation**

Prior to any implementation of Industry 4.0 technology, an organisation must vigorously prepare. Imielski (2022), recommends at least six to twelve months of preparation work prior to implementation, using this time to clearly define the project scope, set milestones and assemble cross-functional teams that work within the existing process. It is also critical to set SMART (Specific, Measurable, Achievable, Relevant and Time limited) objectives that are embedded throughout the business to create alignment between the implementation technical teams and business-driven use cases. Completing these steps can prevent some of the most common mistakes and poor decisions (Gartner, 2021)

### **7.2. Designate Sponsors**

The entire process of implementing a digital twin will require the involvement of a variety of people from different areas of the organisation. However, in the early stages of the process, selecting a small number of employees to become key-users or sponsors that are committed solely to the project can be extremely effective (Gartner, 2021).

The sponsors will be responsible for ensuring the project receives the correct focus and direction throughout the implementation. They must also ensure management are regularly educated and updated on the project's performance while communicating the expected requirements to the implementation team.

### **7.3. Start Small**

A large number of digital twin projects fail because they are too ambitious and can take a significant amount of time to produce any value. Imielski (2022) states that organisations can avoid this mistake by focusing on a specific use case and creating a minimum viable product (MVP). This will allow the business to generate tangible value at low cost and in a short period of time. Additionally, demonstrating a quick return on investment to the company's key stakeholders will help to increase buy-in to the initiative of digital twin (Imielski, 2022).

### **7.4. Ensure the Solution is Modular and Expandable**

While beginning with a specific smaller use case is seen as a good strategy, the long-term goal is to expand digital twin across the business. This should be a gradual adoption that is made possible by putting a modular approach into practice, creating interoperable and compatible

solutions. In most situations, starting small is undoubtedly the best course of action, but the ultimate objective should be to scale up digital twin solutions quickly and take advantage of the full potential the technology has to offer (Imielski, 2022).

## **8. The Impact of Digital Twin**

Implementing digital twin simulation into the aircraft seat manufacturer has the potential to bring significant benefits to the organisation.

### **8.1. Cost Cutting**

Digital twins will enable the seat designers to conduct all tests and simulations in a virtual environment during the product development phase reducing defects during physical production and operation. In the digital context, it is quicker and cheaper to fix issues than it is in the physical world. Engineers will be able to virtually eliminate all future output risks and ensure that the physical object performs exactly as intended.

### **8.2. Streamlined Design**

As discussed in section 3 Aircraft Seat Manufacturer - Product Development Current State), new products can go through several changes before an actual working prototype is created. This procedure is costly as it requires a significant amount of time and resource. Virtual modelling, through digital twin can eliminate these design issues earlier in the process, resulting in more seamless prototyping.

### **8.3. Reduced Time to Market**

Getting to market faster than its competitors is one of the main goals for the aircraft seat manufacturer, this is usually delayed due to long iterations and quality improvements. Digital twin virtual assistance can add value to the organisation by enabling engineer's to develop products virtually and speed up the time to market. This enables the lifecycle of the product to be carried out in a digital environment, where all improvements can be made more efficiently and with ease. These virtual prototypes can verify how its physical counterpart will behave in its real life setting, maximizing development effectiveness and time. As a result, entering the market as soon as production begins.

### **8.4. Improved Customer Relations**

Using digital twin technology, the organisation can prevent potential issues from ever reaching the customer, thus delivering defect free seats and improved customer relations (Sakovich, 2021) Digital twin can also add significant value by assisting the company to deliver on their promises and deliver seats on time.

## 9. Conclusion

Implementation of digital twin into the aircraft seat manufacturer's product development process can be an extremely powerful tool and support the business to drive their products to market in the fastest possible time to satisfy existing customers and potential new customers. However, as with any industry 4.0 technology projects, they can be difficult to plan and implement due to their high complexity. Stringent preparation, both in terms of planning the actual initiative and assigning roles, as well as expectation management and education, are some of the most important best practices of digital twin implementation. Furthermore, if the organisation wishes to scale up, it is critical to stay focused on the business model and focus on the value they can provide, while also constantly evaluating and remaining open to new user groups.

## 10. Recommendations

As we continue to move further into Industry 4.0, applying digital twin technology only to the aircraft seat manufacturer's product development process will not be sufficient if they want to stay ahead of their competitors. The recommendation would be to research and seek guidance on how the technology can support the entire lifecycle of the products (beginning, middle and end-of-life). Furthermore, it is recommended that the organisation further researches industry 4.0 emerging technologies and the possibilities they can provide to ensure they deliver on their business model of the future.

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