COMPETITIVE ADVANTAGES IN THE AEROSPACE INDUSTRY: CURRENT INFORMATION TECHNOLOGIES

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Summary. This article focuses on analysing how the strategic application of modern information technology (IT) serves as a driving force for achieving and maintaining a competitive edge within the airline industry. In response to the growing digital landscape, airlines are leveraging advanced IT solutions to streamline operations, drive innovation, and enhance overall performance. By conducting an in-depth review of existing literature, examining case studies, and engaging with industry experts, the study seeks to uncover critical IT trends and their influence on competitive positioning in aviation. Additionally, it aims to address the challenges and opportunities of IT integration, offering practical guidance for industry professionals to manage the complexities of digital transformation effectively. IT is viewed as a pivotal factor in advancing productivity, with its extensive application playing a crucial role in optimizing production resources and strategic assets. This fosters the ongoing modernization of traditional industries, while also boosting societal productivity and operational efficiency.

Keywords; Digital Transformation in Aviation; Strategic IT Integration; information technology

1. INTRODUCTION

Aerospace is a relatively young industry, just over 100 years old. Yet, because of its role in fostering innovation and setting new challenges for the development of materials and technologies, it can be considered one of the industries that shaped the twentieth century and is a driving force for technological progress. The very beginning of the aerospace era can be dated back to the pioneering work of the Wright brothers in the 20th century. However, the dream of flying was deeply rooted in the minds of mankind before then, for example thanks to the work of Leonardo Da Vinci, who designed the famous flying machine in the 15th century.

The aerospace industry has a rich history and is a driving force behind technological progress. It involves developing, producing and testing flight vehicles, including aircraft and spacecraft. The industry has worked steadily with various other industries such as travel and tourism, logistics, telecommunications, and defense supply, making it one of the largest and most influential manufacturing sectors in the world. The aerospace industry has been a catalyst for technological advances that have led to the development of science and technology. It has also been a major socio-political phenomenon, inspiring innovation and capturing the imagination of people around the world.

In recent years, the industry has undergone a digital transformation, embracing automation and digital technologies to optimize manufacturing processes, increase supply chain efficiency and revolutionize the way aviation operates. This change has led to improved operational efficiency, reduced costs, and increased competitiveness.

The digital revolution presents opportunities not only to increase productivity, but also to enhance aviation safety. Aviation maintenance facilities are increasingly embracing digital technologies such as the Internet of Things (IoT). By connecting sensors to different parts of the aircraft, a network is created that informs teams about the status of individual parts. This technology can be combined with

the use of drones, which make it easy to check for problems on the aircraft from all angles. In addition to these new monitoring technologies, the use of Big Data and information gathered from artificial intelligence can automate data processing and enable quick maintenance solutions. In addition to improving manufacturing processes, the introduction of new digital technologies will force the evolution of every step in the aerospace manufacturing value chain. For example, augmented reality improves and speeds up the design process. It provides valuable assistance to engineers and designers working to increase the capacity of an aircraft while making it lighter and safer. Virtual reality makes it possible to refine the design of even the smallest details without having to go through a prototype phase.

Digitalization will accelerate in the coming years to keep pace with the growing needs of the aerospace industry. The aviation sector is poised to meet this challenge by leveraging its history of innovation and adapting to new competitors and startups that are shaking up the industry and redefining its practices.

The aviation industry is rapidly embracing digital technologies. Initially, these advances improved customer connectivity and user experience through state-of-the-art services. However, the impact of digitalization goes beyond ticketing. Airlines are recognizing the need to introduce information technology across the entire spectrum of the airline industry in order to increase their competitiveness and thereby secure the flow of funds needed to invest in the development and implementation of information technology.

1.1 Evolution of IT in the aviation sector

The air transport sector has benefited from technological innovations that have contributed to its importance to the world economy and to the promotion of other industries. The aviation industry is based on technology. As a result, innovation will always be a key driver of the industry and its thriving supply chain, where technologies are constantly being introduced and explored to continuously improve performance. Innovation affects both the demand and supply side of any business by helping industries to maintain a competitive advantage. In the aerospace industry, innovation is critical for improving efficiency and operational capabilities and for creating value through improvements in air traffic management, advanced materials, more sustainable fuels, energy storage, transition to digital systems and mitigation of environmental issues, which provide new opportunities for the development of the industry [1].

The definition of innovation refers to improvements, new developments or new uses in products, services, processes, and marketing that propose new or additional value to the business and customers. Innovation is a source of value created through the invention, development, production and provision of new market offerings. This process involves dimensions beyond conventional economic considerations, including social and environmental elements [2].

Innovation is crucial for businesses to succeed and is a major source of sustainable competitive advantage. However, to foster innovation and reap the benefits, organisations need to adopt a set of activities and capabilities involving new thinking, strategy, process, and outcomes. In other words, innovation is needed to create 'value', despite its inherent risks. Changing an organisation's mindset leads to a better-informed innovation paradigm. More specifically, strategic thinking improves the understanding and perception of the barriers that are associated with adopting new solutions [3].

Innovation strategy is considered a critical element of corporate strategy because it determines where, when, and what type of innovation needs to be introduced. To maintain a leading innovation strategy, it is essential to monitor markets, technology pathways and organizational processes. Innovation strategy may involve reshaping the corporate ecosystem rather than coping with competition. The innovation process consists of decisions, activities and influences ranging from recognition and satisfaction of a need or solution to a problem, research, development, dissemination, and user adoption. In a particular type of innovation outcome, this process can be unique, complex, and uncertain [4].

Innovation outcomes are widely discussed in the literature and are distinguished into two main types: 'radical' or 'incremental' depending on the intensity or level of innovativeness. Radical or

disruptive innovations include products, services or approaches that change existing markets or create new markets by trading raw performance for simplicity, convenience, affordability, and accessibility. Incremental innovations can be defined as products, services, organizational and marketing improvements that provide new features or new benefits to existing technologies or solutions in the current market [5]. The micro-perspective defines innovation as novelty to the firm or novelty to the customer that adds value, benefits, or changes models [6]. In addition, different innovation outcomes create diverse value propositions from the perspective of the organization and the customer.

Value creation has been extensively analysed in management research and in the literature on benefits, value, performance, and success. The meaning of value and the process of value creation is rapidly shifting from a product-, service-, and firm-focused view to personalized consumer experiences that occur inside the firm and outside markets. Value is also created when innovation is driven by social demand and achieves differentiation, thereby creating more value. Greater value creation depends on a firm's ability to innovate successfully. However, this is often not independent, rather its success depends on other factors that accompany changes in the firm's environment. Drivers of innovation include the firm's policy decisions, linkages, timing, location, allocation of activities across business units and stakeholders, collaboration, learning, integration, scale, and institutional mindset. Therefore, to enhance innovation and value creation, firms need to build on these drivers of innovation to provide a more comprehensive and appealing variety of goods and services than the current needs or wants of their customers, in addition to supporting the perspectives of stakeholders and the organization itself [7].

Value creation has become a complex and multidirectional concept that encompasses multiple perspectives and considers the micro level - customers and groups, the meso level - organisations and the macro level - stakeholders and supply chain networks. Given these different contexts, the inherent potential of innovation needs to be unlocked, managed, and purposefully materialised in order to achieve tangible results. The value creation process is co-created by those who create value and those who capture value, with customers being the arbiters of value. Customers are the foundation for the successful diffusion of innovation that leads to sustained high performance and profitability [8].

From an organizational perspective, value creation refers to new types of production processes, activities, outcomes, benefits, differentiation, competitive advantage, profitability, and long-term success through sustainable development. From the stakeholder and supply chain perspectives, firms are part of ecosystems that influence the quality and scale of innovation development activities, and therefore the ability to co-create innovation enables them to share value through knowledge exchange with one or more parties in return for rewards [7][9].

Airlines, airports and civil aviation supply chains can promote innovation as a source of value creation in order to gain financial benefits through improved technological performance, complementary assets, reduced environmental impacts and offering additional value to passengers. In addition, innovation creates value because of the pressing need for new sustainable development, more personalised services, creating a safer and more secure environment. Previous studies on innovation in air transport have been based on technical approaches. Furthermore, despite the acknowledged importance of innovation in reducing macro problems in aviation, little is known about how these advances are shaping the sector to change the industry towards a more sustainable paradigm. In this context, this research is valuable given the importance of leading product, service and process innovation in the aviation sector; few previous studies have provided a clear and accurate description of how to successfully undertake innovation adoption to create value [10].

1.2 Key IT trends shaping the industry environment

The aerospace industry has established itself as a driver of global technological development and innovation, making engine and aircraft design lighter, quieter and more efficient. However, the industry is facing a paradigm shift due to new future technologies such as robotics, the Internet of Things, unmanned aerial systems, artificial intelligence and the requirement for hybrid and electric aircraft as the industry's response to the climate crisis. Relevant information for this study was sought

using multiple search engines and gathered by reviewing scientific publications and publication reports from governments and professional organizations that report original work in the field of commercial aviation. The selection criterion was to search these publications and cite relevant information that followed industry trends. This paper discusses some of the disruptive technologies of the 4th Industrial Revolution that will impact the civil aviation industry in the not-too-distant future, and the role that technology management plays in enabling organisations to manage their technological capabilities to create a sustainable competitive advantage. The paper also explores the potential dangers of over-dependence on technology, although technology itself has many positive prospects in terms of making life easier but is associated with several drawbacks [11].

2. IT APPLICATIONS IN THE AEROSPACE INDUSTRY

2.1. Data analysis and predictive maintenance

The concept of predictive and prescriptive maintenance in a complex system has recently gained more research attention, especially in the aerospace industry. Prior to the advent of IoT technologies, vehicle maintenance was mainly performed based on predetermined schedules related to vehicle age, number of scheduled cycles, or usage. It was not linked to the real-time status of the vehicle. Schedule-based maintenance is prone to unnecessary vehicle inspections or on-site visits to the service centre. Potential failures may go unnoticed between schedules, and little or no useful knowledge is available to airlines, OEMs, and service centres. A business cannot afford to let assets run to failure because it costs equipment damage and equipment downtime [12].

The concept of prescriptive maintenance in a comprehensive system seeks to mitigate the problems of time-based maintenance. Predictive maintenance has been gaining more research attention recently, especially its application in the aerospace industry. The strength of predictive maintenance lies in its ability to provide predictions at the right time and correctly, which depends on the type of data used to train the models. Uneven data distribution is a common challenge in many classification tasks. For example, when classifying a financial transaction is fraudulent or not. It is likely that most transactions are legitimate and a minority as fraudulent. In this case, the trained data contains very imbalanced examples that reflect the true distribution of classes in the general population.

Similarly, in aircraft predictive maintenance, the imbalance of failure events against normal may exist for failure events and service events. This problem is due to the following reasons. Failure events usually occur infrequently compared to the normal operating condition of the aircraft in service, and there are fewer failure events overall.

The use of aircraft logbook data to predict a potential failure that may lead to a malfunction presents many challenges and has yet to be fully explored. These logs are captured during each flight and contain current data from various aircraft subsystems regarding status indicators and alerts. Therefore, they can be considered as a comprehensive multidimensional time series. Given the aircraft are highly integrated failures are very rare and therefore the distribution of the relevant data containing the previous indicators will be heavily skewed towards the normal (healthy) case. This will pose a significant challenge when using data-driven techniques to "learn 2 relationships/patterns that depict fault scenarios, as the model will be biased towards heavily weighted fault-free results [12].

2.2. Internet of Things for smart manufacturing and supply chain management

Since the Industrial Revolution, the manufacturing sector has played a dominant role in the economies of countries and societies. We are in a new era of the modern Industrial Revolution 4.0, in which, cyber-integrated manufacturing is a matter of urgency. IoT-enabled smart manufacturing provides an interactive relationship between intelligent machines to share data and information, which is essential for complex systems to make real-time decisions about the work environment. In everyday point of view, achieving resource growth and energy efficiency is a key strategy to achieve sustainability in manufacturing [13]. Enterprise organizations are facing many challenges in recent days due to technological advancements and extreme global competition. In order to overcome these

challenges, innovation in their products and processes is essential to enter into sustainable development in the future.

IoT is a technology through which companies are focusing on improving their product and process development. Even though IoT is witnessing tremendous growth in various sectors such as healthcare, energy management, smart retail, agriculture, etc., the implementation of IoT in the manufacturing sector is in its infancy. Most of the manufacturing processes still depend on the third industrial revolution which is called the digital revolution where electronics such as transistors, microprocessors, telecommunication, and computers are emerging.

This revolution has led to the development of automation in manufacturing, such as programmable logic controllers (PLCs) and robots. These measures have paved the way for greater production in industries with less time and cost-efficiency. However, due to high competition and globalization, industries are looking for the next level of technological advancement. New business models embedded in the Internet of Things are enabling organisations to develop innovative products with high productivity. Industries are forced to produce more products using less raw materials and energy. The survey estimates that smart production lines and industries will result in an annual efficiency gain of 3.3, which would lead to 2.6% annual cost savings. This is forcing companies to invest in the Internet of Things, and a recent survey estimated that European companies will spend around EUR 140 billion to revamp the way products are manufactured. A well-designed IoT network leads to informed production in an organisation that connects four essential elements such as products, people, processes, and infrastructure. To enable smart manufacturing integrated into IoT, three main building blocks are required as shown in Figure 1 [14], the first are sensing nodes. The sensing devices that are used in IoT environments can vary greatly depending on the application. It can be a camera to monitor an image, an RFID (Radio Frequency Identification) radio to sense the existence of an object/person, or a simple thermocouple. To measure temperature. The second building block is the embedded processing nodes, which can be a hybrid microcontroller or a microprocessor whose embedded processing takes place in real time. The third is the wired or wireless communication nodes that transmit communication between the two previous building blocks to perform the task. In general, it is a bidirectional communication node.

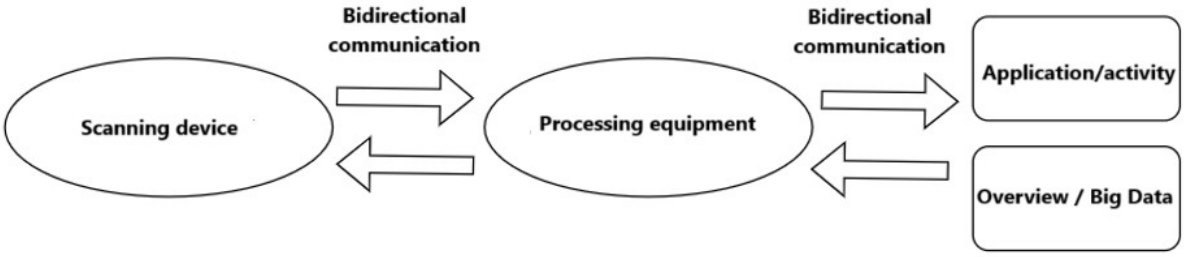

Figure 1 IoT-enabled intelligent manufacturing building blocks

The pervasiveness of IoT-enabled manufacturing is not limited to a specific localized industry segment or value chain process; rather, it is applicable to multiple segments of manufacturing and logistics as shown in Figure 2. The potential of IoT in different segments is shown as follows.

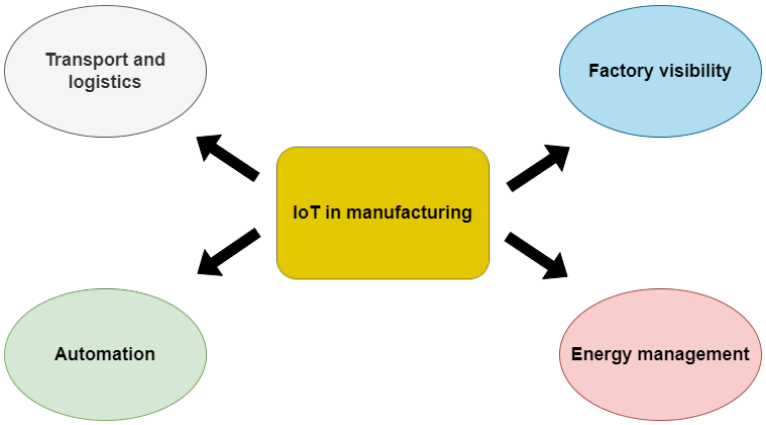

Figure 2 The impact of IoT in the manufacturing sector

2.3. Transport and logistics

In IoT-enabled transport and logistics, products are equipped with sensors along with embedded tags. [15]. As a product moves, its flow can be tracked by different supply chain participants. Further, "Based on the data from the trade records, it is possible to determine whether the product is a trade-in or trade-out item in a given case, the product becomes completely autonomous, and the readers can make different information decisions based on the data. This leads to end-to-end supply chain visibility and warehouse management, ensuring that the product is in the right place at the right time. Optimal fleet management is also possible if fleet downtime is significantly reduced.

3. CONCLUSION

In conclusion, the adoption of current IT in the aerospace industry offers a significant route to competitive advantage. Through the integration of modern IT solutions such as data analytics, artificial intelligence, virtual reality, and the Internet of Things, airlines can increase operational efficiency, streamline processes, improve safety, and deliver innovative products and services to meet evolving market demands. In addition, the use of IT enables better collaboration across the supply chain, supports real-time decision-making, and facilitates predictive maintenance, leading to reduced costs and increased customer satisfaction. As the aerospace industry continues to evolve and face new challenges, the adoption of modern IT solutions will be paramount to maintain a competitive advantage and achieve future success in this dynamic industry.

At the same time, the integration of current IT in the aerospace industry represents not only a competitive advantage, but also a necessity to remain relevant in a rapidly evolving environment. By harnessing the power of big data analytics, cloud computing and advanced simulation technologies, aerospace companies can optimize their operations, improve product development processes, and deliver cutting-edge solutions to their customers.

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