



Adoption of Metaverse in Aerospace Industry: Organizational Perspective

اعتماد الميتافيرس في صناعة الطيران: من وجهات نظر المؤسسات

by

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of the requirements for the degree of
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ABSTRACT

This study aims to identify the factors that influence the adoption of metaverse in the Aerospace Industry. Utilizing the Technology-Organization-Environment (TOE) Framework to develop a deductive questionnaire-based approach. The framework consisted of thirteen independent variables and one dependent variable (Metaverse Use Intention). 13 hypotheses are developed to statistically test the relationships between the 14 variables of the research model. The study adopted a convenience sampling approach, the population focused on the aerospace industry worldwide and on a general organizational type. The results from the data analysis from linear regression analysis suggest that there is no statistical significance on the adoption of metaverse. The descriptive statistics collected offer an understanding of the perceptions and attitudes towards metaverse in the Aerospace Industry. The results show that this study needs to be more focused on specific sectors of the Aerospace Industry and to evaluate the individual perception as well as the organizational perception, utilizing the TOE Framework and TAM Model. The study contributes to innovation in the Aerospace Industry and provide a steppingstone to taking next steps in adopting Metaverse.

ABSTRACT (in Arabic)

تهدف هذه الدراسة إلى تحديد العوامل التي تؤثر على اعتماد الميثافرس في صناعة الطيران. استخدام إطار عمل التكنولوجيا والتنظيم والبيئة لتطوير نهج استنتاجي قائم على الاستنباط. يتكون الإطار من ثلاثة عشر متغيرا مستقلا ومتغيرا تابعا واحدا (نية استخدام الميثافرس). تم تطوير 13 فرضية لاختبار العلاقات إحصائيا بين المتغيرات الـ 14 لنموذج البحث. اعتمدت الدراسة نهجا ملائما لأخذ العينات ، حيث ركز السكان على صناعة الطيران في جميع أنحاء العالم وعلى نوع تنظيمي عام. تشير نتائج تحليل البيانات من تحليل الانحدار الخطي إلى أنه لا توجد دلالة إحصائية على اعتماد الميثافرس. تقدم الإحصاءات الوصفية التي تم جمعها فهما للتصورات والمواقف تجاه الميثافرس في صناعة الطيران. تظهر النتائج أن هذه الدراسة تحتاج TAM إلى أن تكون أكثر تركيزا على قطاعات محددة من صناعة الطيران وتقييم التصور الفردي وكذلك التصور . . التنظيمي ، باستخدام إطار و نموذج &TOE

تساهم الدراسة في الابتكار في صناعة الطيران وتوفر نقطة انطلاق لاتخاذ الخطوات التالية في اعتماد الميثافرس

DEDICATION

This is dedicated to everyone who stood by my side during my rough times. They know themselves...

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Chapter 1: Introduction and Background

1.1 Introduction

After the pandemic eased off and the lockdown ended, the aerospace industry regained its position with an increase in demands. This pandemic uncovered mishap in the current aerospace industry, but it also widened the horizon for new innovative ideas. The air travel demand during pandemic was halted and dropped by 91% (Deloitte Consulting 2020). The streams of revenue, market capitalization and commercial jets were in decline. Uncertainties and risks rose higher than expected. The unaffected part of aviation was the air cargo carriers and freight forwarders, that were used to maintain supply and demand worldwide (IATA 2022). Keeping this in mind, the idea of becoming more sustainable and greener grew. Whether it was to fly less or use varied materials or enhance research to become more robust, the concept of metaverse started rising. This paper introduces the metaverse, its architecture and function in the aerospace industry. In addition, it will provide a steppingstone to start implementing the use of metaverse in the aerospace industry specifically with respect to MRO sector. Ever since Mark Zuckerberg announced the transformation of Facebook into Meta, he emphasized its potential in both personal and professional lives, it slowly began to sneak its way into each company's future framework. Thus, a clear understanding of the metaverse and its structure is a must to build a stable and functioning company within it. Focusing on the UAE, it has been the hub for the future. It has assigned a devoted Minister for Artificial Intelligence (AI), built the “foundation of future” dedicated to incorporating the newest innovative ideas and technologies including metaverse, and announced the relocating of Dubai Economy headquarters and Dubai Electricity

& Water Authority (DEWA) in the metaverse (Gokulan 2022; Staff Reporter 2022a, 2022b; Web Desk 2023).

1.2 Research Gap and Problem

With metaverse being a new topic and concept, many are still unaware of its purpose and potential. The literature review is still lacking and is slowly building its own database surrounding metaverse. The metaverse is very well known in the gaming community as visual aids and player interactions have been exhibiting magnificent aspects. However, when the focus is shifted to other industries, whether its healthcare, automotive or aerospace; the data supporting metaverse falls drastically. To properly implement metaverse within any work environment, an understanding of multiple organizational factors is necessary to contribute to metaverse effectiveness. Investigating the literature review will provide a proper baseline in regards to defining metaverse and its development. However, the literature review is still lacking on an organization's perspective on the use of such technology in the work aspect, specifically in the Aerospace Industry.

1.3 Research Aim, Questions and Objectives

1.3.1 Research Aim

The research aims to determine the potential of adopting metaverse in the aerospace industry by examining the willingness of organizations to adopt and adapt to the technology. The research will align factors that aid in and mitigate the adoption of metaverse within the aerospace industry and the steppingstone to develop a framework.

1.3.2 Research Questions

To reach the aim in section 1.4.1, the research will answer the following questions:

1. What are the key variables, structure and technologies associated with metaverse?
2. What are the current technologies being used in the aerospace industry?
3. How will the metaverse support the aerospace industry?
4. What are the factors/variables that affect the adoption of metaverse in aerospace industry?
5. What are the practical and theoretical recommendations to aid in metaverse adoption and developing its framework?

1.3.3 Research Objectives

To be able to answer the questions in section 1.4.2, these are the main objectives of the paper:

1. Define metaverse according to the literature, including its key variables and structure.
2. Identify the current innovative technologies and virtual aspects used within the aerospace industry.
3. Identify the key factors that impact the adoption of metaverse based on organization perspective.
4. Analysis of the aerospace organization's perception and willingness to use metaverse.
5. Provide practical and theoretical recommendations to align factors that aid in and mitigate the adoption of metaverse within the aerospace industry and the steppingstone to develop a framework.

1.4 Significance of Research

The significance and value of this work is the steppingstone into considering the metaverse as a potential future in any work environment. It takes into consideration an organization's perspective to develop and become more productive. The aerospace industry is repositioning itself in the world to support the dynamic and always changing environment. This study will support and add to the limited information on metaverse in the aerospace industry as well as the limited information on the employee's willingness to adapt to incorporate the latest innovations.

1.5 Research Outline/Structure

Chapter One: Introductory chapter. This chapter introduces metaverse and its potential by outlining research background, aims and objectives, the research questions, as well as explaining the research problem, framework, and significance.

Chapter two: Literature review. The second chapter of the research involves an intensive literature review of defining metaverse and its potential, explaining its architecture and the process of how it is developing throughout the years. It then further investigates the Aerospace Industry and its experiences with innovative technologies and the current challenges it is facing.

Chapter three: Research Methodology. The research conceptual framework and variables to be studied are outlined in this chapter. The research paper follows a quantitative methodology using questionnaires to collect data. A pilot study was conducted to reaffirm the questionnaire. After that, a fully detailed description of methodology is created.

Chapter four: Data analysis and Discussion. This chapter examines data from the survey and uses SPSS to analyze it. The section explores and examines SPSS results such as correlation,

regression, validation, reliability, and significance of independent variables to the dependent variable, considering the strength and extent of support between them. The findings are also analyzed considering the literature and in relation to Metaverse in Aerospace Industry.

Chapter five: Conclusion and Future Recommendations. This chapter highlights the key points of the study and summarizes the most essential elements aligning the research goals, objectives, and purpose. It also provides further recommendations to better enhance the study.

1.6 Chapter Summary

This chapter initially provided a brief introduction on the development of the topic” Adoption of metaverse in the Aerospace Industry”. Afterwards, it explained the significance of this research topic and the research gap that will be filled with this study. It included the research aim, research questions to be answered, and the objectives and goals of the research. Furthermore, the overview or outline of the paper was depicted. In the next chapter, an extensive review of the literature takes place.

Chapter 2: Literature Review

2.1 Introduction

As mentioned in the first chapter, the metaverse is a fairly new concept that lacks any theoretical data. In this chapter, a systemic literature review takes place, starting with defining the metaverse, its features and architecture, and means of developing it. Later on, the focus shifts to the Aerospace Industry. Starting with a brief introduction to the industry, following a brief outline of the current innovations being considered within the industry, and the challenges it is currently facing. Finally, the focus shifts to evaluating the metaverse's implementation into the Aerospace Industry. Using the information gathered, a conceptual framework was developed specifying the independent factors that would affect the dependent variable, which is the adoption of Metaverse.

2.2 Metaverse Definitions

Table 1: Definitions of Metaverse.

Definitions of Metaverse	Reference
A virtual space created using technologies such as blockchain, augmented spectrum, IoT...etc. Everything in the space is virtual except for the user.	(Abrol, 2021)
A 3-dimensional digital structure/space that is shared by everyone and does not belong to a single platform. It is a fully immersive shared cyberspace.	(Dionisio et al., 2013)

An interconnected multi-user platform that enables interactions through immersive environments. Consists of multiple virtual worlds, where users can jump or travel through them.	(Mystakidis, 2022)
A virtual, open, immersive, self-organizing, self-monitoring and untethered space designed to “remove” the time and space barriers by fooling the users’ visual sensory.	(Jaynes et al., 2003)
A virtual universe where avatars (or users) can socialize, explore, shop and/or even attend business meetings.	(Dwoskin, 2021)
The “blending” of the physical attributes with the digital technologies to create a virtual space. Its convergence of technologies with the internet and interaction through extended reality.	(Lee et al., 2021)
The “next generation of the internet” provides a virtual space that is fully immersive, spatiotemporal, self-sustaining, and shared by people, where they can work, socialize, play and shop-in.	(Wang et al., 2022)
An idea that hasn’t matured yet to exist where the real time accessible 3-dimensional environment and virtual environment will be the future medium or space for social and business-related activities.	(Hall & Li, 2021)

The fusion of physical and virtual worlds together where the virtual space is a persistent feature in people's lives by the convergence of 3D technologies with virtualization.	(Smart et al., 2007)
The "evolution" of internet that supports a more of "inhabitation" of the spectrum of the real world into the virtual world	(Byrnes, 2022)

2.3 Metaverse Description and Features

The "Metaverse" Hype started with the announcement by Mark Zuckerberg of the transitioning of Facebook to Meta (Thomas 2021). Following which, multiple social media platforms supported and followed the transition, including Instagram and WhatsApp. So, what is the metaverse? "Metaverse is a post-reality universe, a perpetual and persistent multiuser environment merging physical reality with digital virtuality" (Mystakidis 2022).

It is a virtual space that supports the interaction of multiple users using a device/controller, or a virtual universe that encompasses and extends beyond multiple worlds, augmented reality, and virtual reality (Park & Kim 2022). Let's begin with a simple example, a game where you get to join forces and compete with other players, this game occurs in the metaverse. The metaverse can provide a range of innovative ideas and emerging technological changes in the vast fields of business, education, personal and professional life. It consists of different layers and each layer can opt to cater to a specific audience. It is a shared space, created by convergence of real and virtual reality, where users can interact with each other and digital objects using avatars (Meehan 2022).

The term, Metaverse, was first mentioned in 1992, in a science fiction book by Neal Stevenson (Stephenson 1992). The concept was fictional and was adopted in movies as part of the future (Cheng et al. 2022; Mystakidis 2022; Schwirn 2022; Zhang et al. 2022; Zhao et al. 2022). Essentially, it is the development of a virtual environment using advanced technologies including Mixed Reality, Artificial Intelligence, web technologies (e.g., blockchain), and 5G networks, depicting the unification or convergence of both, the physical and digital worlds (Lee et al. 2021).

Although this portrays the outlook of the metaverse, there still are some hidden features. In addition to its being immersive and providing interaction and collaboration between users, the metaverse is self-monitoring and self-configurative (Jaynes et al. 2003). In the metaverse, users can interact with each other in real-time, participate in virtual experiences, and engage in commercial activities as well. The metaverse is expected to bring various virtual environments together and create a seamless, immersive experience for users. In addition, for it becoming an entertainment and social interaction platform, it is also seen as an e-commerce, educational, and governance platform (*What is the metaverse?* 2017; Kye et al. 2021).

The metaverse stands out from the current online platform because of its unique features (White 2021; *What is the metaverse?* 2022). Some of the features are currently present in the gaming industry; Oculus, Roblox, PokemonGo. Others are still being adapted using the latest innovative technology. The features can be seen below (Smart, Cascio & Paffendorf 2007; Lee et al. 2021; Park & Kim 2022; Zhang et al. 2022; Zhao et al. 2022):

1. Decentralization & Persistence (Bobier et al. 2022; Mourtzis et al. 2022a): the metaverse is designed to be self-sufficient and self-sustainable with no centralized entity; thus,

allowing it to exist and evolve even with no users. The decentralization aspect gives control and ownership to its users.

2. Heterogeneity (Jaynes et al. 2003; Wang, Su, Zhang, Xing, Liu, Luan, Shen, et al. 2022): to promote a dynamic and engaging virtual world, heterogeneity is essential as it provides users with control over their own digital identities and experiences within the metaverse. It enables users to explore and engage with a wide range of virtual content & experiences and encourages innovation and creativity in the development of new digital environments and objects. This also creates new opportunities for social interaction and community building, as users with diverse interests and backgrounds can come together and engage with each other within the shared virtual space. Overall, heterogeneity is a key feature of the metaverse that contributes to its dynamic and engaging nature and has the potential to transform a wide range of industries and sectors.
3. Interoperability (Chang et al., 2022; Jaynes et al., 2003; L. U. Khan et al., 2023): The metaverse is an open platform that allows the interoperability or integration between systems, platforms, and virtual worlds. This provides users with the ability to move seamlessly between different virtual worlds and experience different aspects of the metaverse.
4. Scalability (Jaynes et al. 2003): with the assistance of different technologies, this feature allows the metaverse to accommodate additional users, applications, and assets. It promotes and supports the growth of the metaverse.
5. Hyper-Spatiotemporally (Yang et al. 2023): as it enables users to experience new and engaging forms of entertainment, education, and social interaction without the constraint of time and space. It allows the transformation of industries and creates new opportunities for business and commerce; enabling companies to create and promote

immersive and interactive brand experiences, product demos, and other marketing initiatives.

6. Immersive & social interaction, and multi-user environment (Chang et al., 2022; Jovanović & Milosavljević, 2022; Shin, 2022; Zhao et al., 2022): the metaverse is a virtual space which allows people to simultaneously interact with each other from different access points across the world. In addition, it provides the users with a full immersive experience within virtual space.
7. Avatars (Dionisio, Burns & Gilbert 2013; Zhao et al. 2022): users in the metaverse are represented by avatars, which they customize according to their style and interests. Each user can have multiple avatars to use.
8. Virtual economy (Belk, Humayun & Brouard 2022; Cheng et al. 2022; Gilbert 2022): the metaverse will comprise of an economy parallel to the real-world, where enterprises grow, inflation occurs, and interest rates change. The virtual economy is currently comprised of crypto-currency and NFTs with explicit ownership rights.
9. Multi-platform compatibility (Dwivedi et al. 2022): users can easily access the metaverse via computer, VR or AR. This highlights an important feature; cross-platform compatibility, which allows access from different devices and access points in the world.

To achieve these features a detailed and robust architecture or infrastructure is required. The next section will go into detail on the requirements to build such a robust infrastructure.

2.4 Metaverse Architecture

2.4.1 Overview

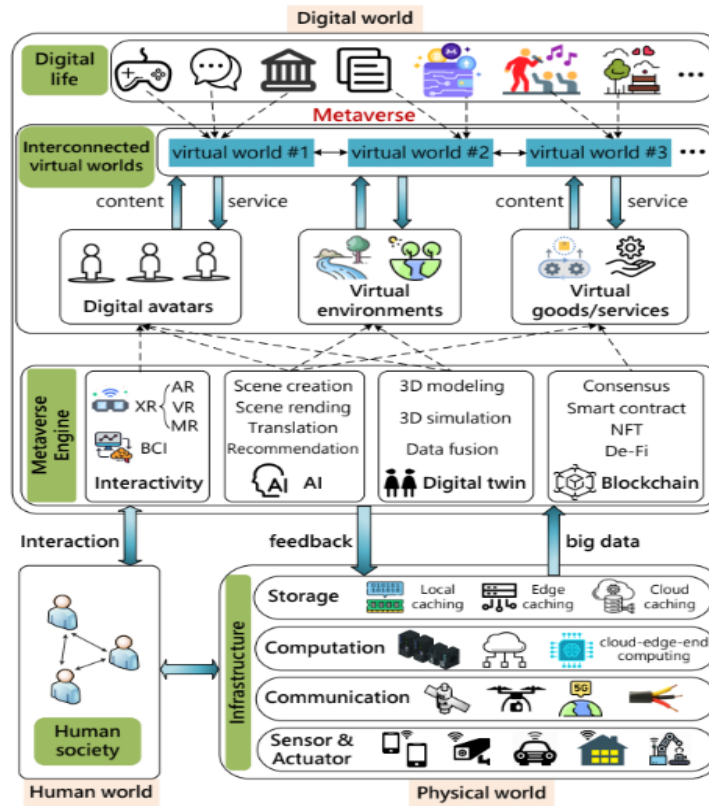


Figure 2-1: Architecture of Metaverse (Wang, Su, Zhang, Xing, Liu, Luan & Shen 2022)

Figure 1 shows the overall architecture of the metaverse that clearly displays the immersion, interoperability, persistence, scalability, heterogeneity, hyper-spatiotemporally and user interaction of the Metaverse (Wang, Su, Zhang, Xing, Liu, Luan & Shen 2022).

The architecture shows the connectivity and the dependence of the different worlds on each other. It is further broken into the three worlds interacting with each other: The Human World, The Physical World, and The Digital World.



Figure 2-2: The Human World.

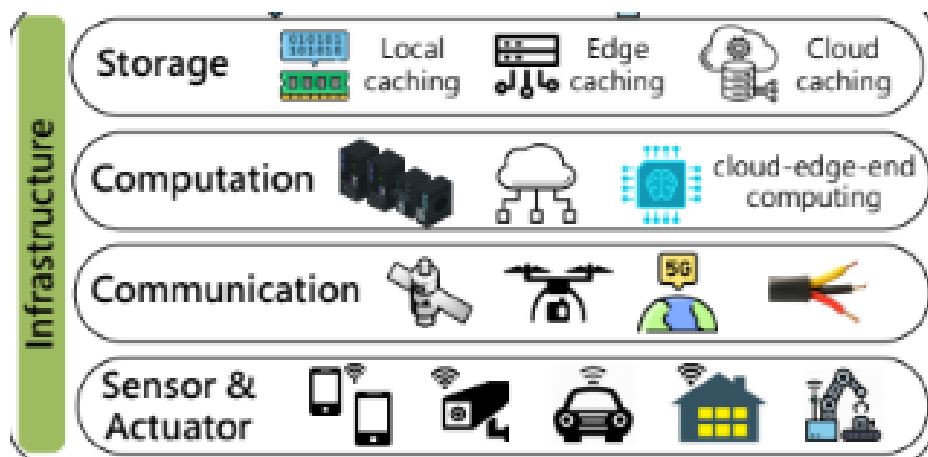


Figure 2-3: The Physical World.

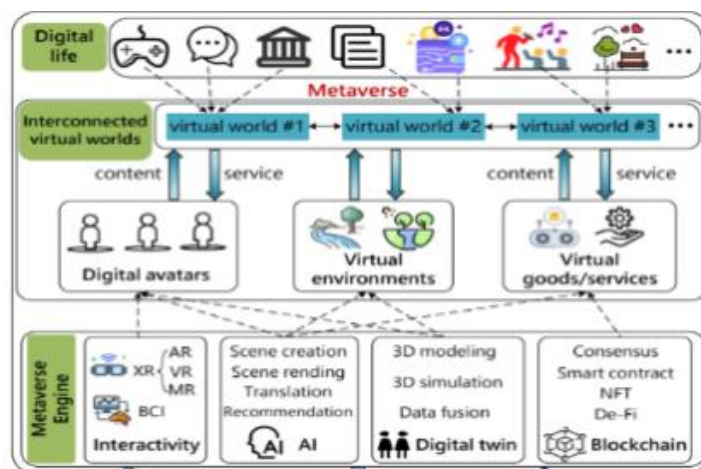


Figure 2-4: The Digital World

Human World infrastructure:

As highlighted in Figure 1.1, this world represents human society, where and how different individuals interact daily.

Physical World infrastructure:

The physical world, as shown in Figure 1.2, includes various physical entities, whether it's the natural landscape or man-made objects (technology and non-technological items/devices). From a metaverse perspective, the technological objects include the storage of the data, codes & algorithms, the computational /computers/servers processing the algorithms, and IoT devices that allow communication between users and other devices(*The Metaverse Overview: Vision, Technology, and Tactics* 2022).

Digital World infrastructure (Metaverse):

We can see in Figure 1.3; this primarily consists of 3 subcategories:

- Themes of each individual virtual world created: entertainment, commerce, business...
- The interconnection between the virtual worlds, users, and services.
- The Metaverse engine, that includes characteristics, technology, algorithms, cloud computing, and databases.

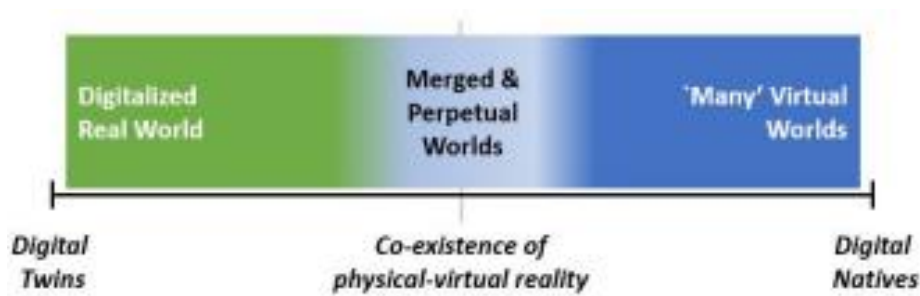


Figure 2-5: The Digital Spectrum.

As seen in Figure 2, there are three stages or segments that are required to create the metaverse experience— Digital Twins, Digital Natives, and the Co-existence of Physical-Virtual Reality (Lee et al. 2021):

1. Digital Twins:

At this stage, a copy of the physical world is encoded digitally, creating a “long-scale & high-fidelity digital models & entities” (Lee et al. 2021). The physical part of objects, including the function, shape, temperature, and other features are coded into the digital platform, in addition to the laws, rules and regulations. The physical and digital worlds become connected via data. This stage is broken into the following steps:

- i. Digital Model: there is no interaction with the physical entity, just the digital replication.
- ii. Digital Shadow: there is interaction with the physical entity, the digital representation.

This virtual representation or replica of the physical world is done by an innovative technology known as Digital Twins. Within the virtual environment, Digital Twins allows users to create real world simulations and interact with the virtual environment. This technology is not new, it

is currently being used in multiple industries including aerospace, healthcare, automotive and more (Li et al. 2022).

The Digital Twins technology in the metaverse has played a vital role in transforming the way products and services are designed, tested, and operated. A physical object or system can be virtually replicated then simulated to determine its behavior and performance. The object can include an engine used in an aircraft or automobile or a complete manufacturing plant. It allows access to the replica by multiple users to promote collaboration on a project. The changes made on a physical object or system can be updated in real time to the virtual environment (Li et al. 2022).

Benefits of Digital Twins Technology (Khajavi et al. 2019; Madni, Madni & Lucero 2019; Lee et al. 2021):

- Promotes real time collaboration of remote engineers, designers, technicians, and work on a virtual replica thus eliminating physical prototypes.
- Save time and money on the prototype development process.
- Promotes sustainability as virtual prototypes lower the environmental impact of their physical counterparts.
- Promotes better performance, safety, and reliability by the product as the different virtual simulations created can help in detect early issues.
 - For example: in the aerospace industry, Digital Twins technology can be used to simulate the behavior of an aircraft under different weather conditions, helping pilots and engineers prepare for different scenarios (Brownlow 2022).

- Promotes remote monitoring and maintenance of physical objects or systems, which enables technicians to detect and diagnose issues remotely, reducing downtime and maintenance costs.
 - For example: in the manufacturing industry, Digital Twins technology can be used to monitor and maintain the performance of a production line. This enables technicians to identify and resolve issues before they affect production (Ibrion, Paltrinieri & Nejad 2019).

2. Digital Natives (Lee & Gu 2022):

Digital Natives are individuals who grew up using technology and are used to its constant presence in their lives. They are usually the force behind creating and adopting the newest technologies. In the metaverse, they are likely to be comfortable with virtual reality, augmented reality, and other immersive technologies; in addition, they are familiar with online communities, social media and understand digital communication. They will be the main creators or promoters of metaverse growth.

Benefits of Digital Natives in the metaverse(*5 Traits of a Digital Native* 2017) :

- Strong sense of identity in virtual environments.
- Ownership of the environment, so they take responsibility to develop social structure of different communities.

Digital Natives are the key drivers in developing the metaverse, due to their strong familiarity and current belonging to the innovative technologies. In the metaverse, these Digital Natives will be represented by their own personal avatars.

3. Co-existence of Physical-Virtual Reality:

At this stage, the metaverse can be self-sufficient, self-sustaining, independent, and able to interact and develop from the physical world. Co-existence means that different individuals, communities, and cultures exist alongside each other within the metaverse (Wang, Wang, et al. 2022).

Benefits of achieving Physical-Virtual Co-existence (Mourtzis et al. 2022b; Wang, Wang, et al. 2022):

1. Metaverse is self-sufficient, self-sustaining, and independent.
2. The metaverse culture promotes respect, empathy, understanding, and collaboration between different users or Digital Natives.
3. Metaverse is accessible and inclusive to all people, regardless of their background.
4. Clear rules and guidelines are in place.
5. Safety measures are in place.

2.4.2 Metaverse Technologies

A few essential technologies including but not limited to Web3, Blockchain, Extended Reality, Artificial Intelligence, Cloud Computing, IoT, etc. These technologies help develop the main engine that runs the metaverse and controls its stability, allows the connection, interaction of different virtual worlds, and promotes new experiences.

I. Blockchain or Distributed Ledger Technology:

Blockchain or Distributed Ledger Technology is, simply put in words, a ledger with a history of transactions that cannot be altered or modified. It is a collection of data that is placed in blocks and each new block is attached to the end of the chain. The data includes all legit transactions

or information processed and confirmed by a computer. Blockchain promotes a decentralized and robust attribute when embedded into a system (Gadekallu et al. 2022).

It is a critical component of the metaverse structure as it will enable the development of decentralized and secure digital environment, specifically the virtual economy. The blockchain will provide secure transactions and maintain the ownership of assets in the metaverse. This virtual economy will enable users to buy, sell, and trade both goods and services. In addition, it will maintain a legitimate 'ledger' on all the transactions which protects the assets of each user as well as provide secure transactions (Gadekallu et al. 2022).

Benefits of Blockchain in metaverse (Hayes 2023):

- Development of decentralized and secure transaction system.
- Validation and recording of each transaction via distributed network of nodes.
- Highly improbable to manipulate or change the blocks or data. If a block is altered, it will be obvious as it will stand out from the rest, and others will remain uniform.
- Any user can track and validate the virtual currency as the blocks are public and accessible to all (reduces fraud and provides transparency).
- Creates smart, self-executing contracts, that provide negotiations and force the agreements to be held between the users (allows the automated payment and the delivery of goods and services between users).

When it comes to implementation, a series network of decentralized nodes is employed first to validate and secure the blockchain. To support the virtual economy, a virtual currency (cryptocurrency) specific to metaverse needs to be developed or designed. This will allow selling, trading, and buying within the virtual economy, with recorded and validated transactions in the blockchain. A system or process needs to be implemented, to ensure stability, which can

adjust the virtual currency rates as the demands differ—as is the role of the Central Banks in the current economy (Badrudjoja et al. 2022).

One of the main issues that worry users about blockchain is the fact that it is public, as some of the data should be private and not accessible to the public. A process is required to make sure that users' identity as well as their private transactions are encrypted and/or anonymous (Yang et al. 2022).

II. Extended Reality:

Extended reality is quite common these days, especially in the gaming industry with the introduction of innovative technologies using VR glasses and game controllers. Extended reality consists of the following (Lee et al. 2021):

1. Virtual Reality (VR): enables users to immerse themselves in a virtual environment that could be an exact replica of the physical world or an imaginary digital world. VR offers a sense of presence and interaction within virtual space. VR can be used in multiple industries including healthcare, aerospace, gaming...potentially any professional or entertainment industry (Sheldon 2022).
2. Augmented Reality (AR): provides a 'hybrid' environment, where virtual content is displayed or portrayed in the physical world. It allows users to interact with the digital content in the actual world, one of the best examples is the game "Pokémon Go", whereby you could capture fictional Pokémon's using your smartphone. In the metaverse, this can be provided via a smartphone or smart glasses to have a more hands-free experience (Kipper & Rampolla 2012).

III. Artificial Intelligence (AI):

(Mccarthy 2007) explained AI as “the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable.” AI gives a computerized device the capability to function as a human brain or to exhibit human intelligence. Movies have been dictating AI as science fiction for years. It began as a theory and currently can be seen growing and adopted for the future. As seen in the figure, AI has different subsets that allow it to function including Machine Learning (ML), Neural Network (NN), and Deep Learning (DL) (Lowe & Lawless 2021).

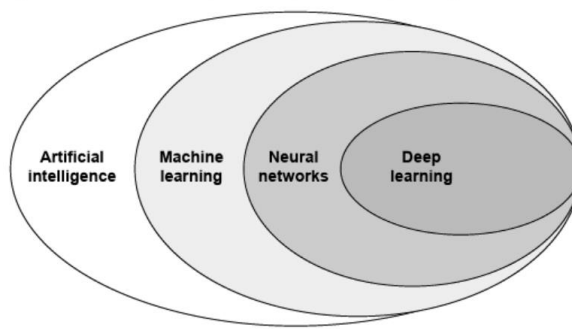


Figure 2-6: Artificial Intelligence Subsections (Lowe & Lawless 2021).

AI and its subsets are essential in the metaverse to program some characters known as NPC, non-player characters. These characters are used to enhance the experience within the metaverse, providing a more realistic experience. NPCs can exhibit complex emotions and behavior which provides a more authentic interaction (Merrick 2008). In addition, AI helps in creating a more dynamic, interactive, and adaptable environment. The virtual environment can simulate more realistic principles of physics such as weather changes, sunrise/sunset, landscapes, nature, and other factors that are in constant change in the physical world.

In addition to creating and developing the metaverse's interactive environment, it will generate a substantial amount of data that requires real-time processing to maintain its decentralized, stable, robust, secure foundation. AI can provide such functionality as it would have the coding to do so (Park & Bae 2022).

IV. Cloud Computing (CC) (Khan & Al-Yasiri 2016)

Cloud computing (CC) infrastructure is used to support the large-scale processing and storage requirements of the metaverse, as well as to enable real-time collaboration and interaction between users (Nabil et al. 2018). CC provides users with new means of storing, processing, and accessing data over the internet. CC provides the data centers, software, analytics, networking equipment and servers to users as long as there is an internet connection (Awada et al. 2014).

For the metaverse, CC can support processing at a large scale and data storage. CC has multiple advantages (Nabil et al. 2018):

- Scalability/Flexibility: which allows the user to quickly add or remove computing resources as they see fit. If metaverse requires extra resources as the number of users or virtual worlds increase, the scaling up can occur simultaneously with the additional numbers.
- Cost effective: CC follows the concept of 'pay as you use'. If at one point, you do not require as many computing resources as you usually use, the payment will automatically decrease, thus saving users on expenses.
- Convenience: CC gives users the ability to access the computing services anywhere, anytime and on any device. The main requirement is an internet connection.

2.4.3 Metaverse Accessibility

How will you access it?

To access any online platform, inputting credentials is required which is unique to each user; metaverse will have a similar concept. The access point will be distinctive to each user as a personal profile known as the “Home Space” (Zuckerberg 2021). From there, the user can access other virtual spaces, including public or private events using an invitation. In addition, a user can invite others into their Home Space for a specific timeframe and with limited access. Each user will be depicted as a single or multiple avatars personalized to their preference (Sharma 2022).

Ownership of digital objects will be applicable as well as charging of specific services and goods using a unique cryptocurrency developed specifically for the metaverse (Zuckerberg 2021). The metaverse, being diverse in the way it is used, is built to accommodate a vast number of users in both their professional and personal lives. To support these profiles and accessibility certain details and technicalities are essential. These consist of internal and external support, including servers, computers, programmers, sensory devices and much more.

Requirements to access any Metaverse or Virtual Space:

- Hardware (Deloitte China 2022).

This is one of the main components, as the metaverse will provide advanced interaction, graphics, processing, and computing. To access and enjoy uninterrupted metaverse; heavy-duty hardware that can handle running such a software is essential. This could come with a highly costly as these Hardware are fairly new. Thus, developers are currently working to create cost-

efficient and accessible hardware. Another option is the offloading of the CC on the user's personal device thus being able to use less expensive hardware.

- Internet Connection (Deloitte China 2022).

To avoid any lagging or delays in processing, a high bandwidth of internet connection is required. Metaverse developers, can create a network that requires less bandwidth that can be more accessible or an offline mode that users can access in the metaverse such as their 'Home Space.'

- User Interfaces (Deloitte China 2022),

The metaverse is a highly dynamic and immersive space which requires a user-friendly interface to allow for easy navigation and interactions with the environment. These could include but are not limited to voice commands and hand gestures.

- Security (Deloitte China 2022).

One of the main concerns of any virtual environment user is the privacy and security of their personal data. Metaverse developers need to embed a robust security protocol to prevent any data breach and unauthorized access. This should also be supported by multi-factor authentications, safeguards, encryption, and other protocols within the metaverse.

In the next section, the paper will describe the Aerospace Industry and the uses of an innovation such as Metaverse in it.

2.5 Aerospace Industry Future

2.5.1 The Aerospace Industry

The aerospace industry is divided into many segments, airlines, clients, first Sub Tier suppliers, 2nd Sub Tier suppliers, Maintenance Repair and Overhaul (MRO), production, design, manufacturing, and others. Each segment has its own specifications and requirements and can be broken down further more. The Aerospace Industry is highly regulated by multiple auditing entities both locally and internationally. These entities help maintain the safety and reliability of the aircraft. Some of the main entities are:

- Federal Aviation Administration (FAA)
- European Aviation Safety Agency (EASA)
- International Civil Aviation Organization (ICAO)

The regulations are compulsory for Aviation Safety and compliance by the aviation industry is mandatory. However, these regulations are always checked and evolving to fit the new age of technology and sustainability.

The Aerospace Industry is also known to be one of the most innovative and rapidly growing industries in the world, it always explores new means to revolutionize aircraft design and manufacturing of parts and enhance the efficiency of its operations.

2.5.2 Current Innovations in The Aerospace Industry

One of the widely used tools in the Aerospace Industry is AI. AI is being used to enhance and improve the safety and efficiency of an aircraft, passengers experience, and the support pilots

in the cockpits (Abubakar et al. 2022). It is currently in the development stages and being configured to assist with the following and other (Abubakar et al. 2022):

- Identify and prevent potential hazards that could be a risk to the aircraft or flight, such as a flock of birds or other aircraft.
- Reduce fuel consumption and travel time by optimizing the flight route.
- Personalize the in-flight services and/or products, to enhance the passengers' experience.

3D printing or Additive manufacturing (AM) is a process that uses a digital design to create 3-dimensional objects. 3D Printing is used in the aerospace industry to produce critical, complex, detail specific, stronger and lightweighted aircraft parts. It can also be used to produce on-demand parts at a fast pace, which also supports the procurement turnover time and reduces the costs of supplies. In addition, it supports the industry to be more environmentally friendly as it produces less waste than the traditional methods (Barroqueiro et al. 2019; Karkun & Dharmalingam 2022).

As online platforms and the cloud are being used more often across the world, one of the most adopted technologies is cybersecurity. It is used to protect the systems from any cyberthreats, such as hacking, overriding the systems, blackmailing...etc. Cybersecurity also has a huge impact in the Aerospace Industry from protection of any cyberthreats or attacks. These include theft of sensitive data, financial losses, hijacking of flights, flight disruptions, and aircraft grounding (Kumar & Capstone 2014; Goutam 2015). The Aerospace Industry (Ukwandu et al. 2022a) is putting more effort to enhance its cybersecurity positions by implementing a variety of measures, including but not limited to:

- Cybersecurity technologies investments

- Constant updates and assessment on current cybersecurity
- Training employees training on cybersecurity

Another innovation adopted by the industry is sustainability. This focuses on the development of aircraft with less emissions and fuel consumption aircraft, the use of more sustainable composites, enhancing the efficiency of the aircraft's operations, and others (Banke 2020). Another way is to reduce the use of vehicles for in city transportation, by developing Advanced Air Mobility (AAM). AAM is a small fully automated aircraft that aids in the transport of cargo or people (*Urban Air Mobility (UAM)* 2023).

Aerospace engineers use an innovative tool known as Biomimicry where they use nature for inspiration to help them in designing aircrafts that are more efficient, sustainable, and safe (Rashidi et al. 2019). For instance, Airbus A330neo wingtip design was inspired by the shape of a shark's fin, this helps the A330neo reduce air drag and lower noise pollution (*Winglets: a tip-top solution for more efficient aircraft* 2017; Ros 2023).

One of the currently researched innovations is the use of smart materials. These materials have the ability to sense and respond to changes in the environment. If used on the aircraft, it can potentially self-repair and/or develop new means to control the aircraft during flight (Wang et al. 2023).

2.5.3 Current Challenges in Aerospace Industry

The aerospace industry is a crucial component of global transportation and technological advancement, responsible for the design, manufacturing, and maintenance of aircraft, spacecraft, and related systems. During the lockdown, almost 60% of the global aircraft fleet were grounded for months at a time (SATAIR 2021). Airlines, like other businesses, had to cut

costs and lay off employees. The MRO sector in the aviation industry started optimizing their in-store materials rather than ordering and maintaining the typical threshold. Post-lockdown, the aviation industry required considerable time and effort to get back to its pre-pandemic levels or even close to them. The airlines had fewer employees even though the MRO sector had depleted material and human resources, leading to flight delays and cancelations. causing flight delays and cancelation, MRO sector had low employees and materials were depleted (Constanza, Prentice & Sargent 2023). The suppliers were overwhelmed by the number of requests to replenish the stores. In addition, the aviation industry faces numerous challenges that can impact its sustainability and growth. Below are some of the current challenges in the aerospace industry:

1. Environmental Impact (Directorate General for Communication 2023): aviation companies are currently competing to obtain a more eco-friendly and sustainable aircraft. Especially with the growing global awareness of climate change. There is an increasing demand for eco-friendlier and sustainable aviation. The aviation industry is investing to reduce the carbon footprint and noise pollution. This is supported with the adoption of new technologies and innovations, whether in the designing of aircraft or maintenance and repairs.
2. Supply Chain Disruptions (Moosavi, Fathollahi-Fard & Dulebenets 2022): the aerospace industry depends on a global supply chain that can be disrupted due to political issues, natural disasters or, as in recent years, a pandemic. The COVID-19 pandemic caused significant supply chain disruptions, resulting in delays in production, maintenance, and replenishing aerospace supplies.

3. Regulatory Compliance (Rademan 2023): the aerospace industry is heavily regulated and that is time-consuming and expensive. These regulations are in place to ensure the safety and security of employees and consumers. The regulations are reviewed and updated on a regular basis which creates uncertainty and impacts the competitive and innovative nature of the industry.
4. Technological Advancement (Pavluk et al. 2022): the aerospace industry is constant development and innovation focusing on new technologies. This requires a significant amount of investment in the research and development department. However, it gives companies an edge with new opportunities and challenges.
5. Cybersecurity (Ukwandu et al. 2022b): as the aircraft systems are more dependent on digitalization, it becomes more vulnerable to cyber threats. Thus, cybersecurity is a top priority for the aerospace industry, since any cyber-attack can impact and compromise systems, which results in delays, and impact safety.
6. Talent Shortages (Orloff 2022; Gates 2023): as the aerospace industry grows, the required skilled workforce is decreasing. More engineers, technicians and other specialized workers are needed, which is challenging. The newer generation are unmotivated to join the aviation industry as well as the increase in cost to train the ones who join.
7. Cost Pressures (Bryan 2018): the aerospace industry is facing an issue to maintain profitability, due to the increase in cost with labor, material prices, and compliance with regulations. In addition, investment to keep up to date with innovation and development.

These major challenges are the current concern of the Aerospace Industries; however, there are more challenges that arise daily. To face the prementioned challenges collaboration and

innovative solutions are needed. Another point of view of these challenges is that they promote development and growth opportunities.

2.5.4 Metaverse in Aerospace Industry

The aerospace industry has been a hub of pushing the boundaries when it comes to flight, lately it has been seeing a jump with technological innovations. With the emergence of the metaverse, there are exciting new opportunities for the aerospace industry to use the metaverse with its vast potential to support research and development, training, and collaboration (Dwivedi et al. 2022).

Some of the potential applications in details can be found below:

1. **Flight Simulation and Training:** pilots and aviation professionals and experts require constant training and practice to “smooth their rough edges” and to cope when placed in a sudden challenging environment (i.e., change of weather). The metaverse can support the safe training in a realistic, controlled, and immersive environment and setting for flight simulation and training (Jeon 2015).
2. **Aircraft Control Remotely:** The metaverse can potentially allow the control of drones and other aircraft remotely, allowing operators to control these vehicles from a safe location. This can be useful in a range of applications, from aerial photography and mapping to support search and rescue operations (*Urban Air Mobility (UAM)* 2023).
3. **Maintenance and Repairs:** when it comes to any maintenance and repair of any part of the aircraft whether it is in the same area or located remotely, metaverse can allow mechanics and technicians to virtually map, assess, diagnose, and troubleshoot any issues with the aircraft. This cuts down on time and costs whether it is on traveling, or any repair mistakes that can occur (Malecaj 2021).

4. Air Traffic Control: To improve the efficiency and safety of air traffic management, moving the air traffic control system to the virtual space in metaverse supports the monitoring and managing of air traffic space (METAVERSE AVIATION: HOW AVIATION INDUSTRY CAN UTILIZE THE POTENTIAL OF METAVERSE?, 2023).
5. Passenger Experience: The metaverse can enhance the passenger experience, allowing travelers to explore and interact with virtual environments and experiences before, during, and after their flight. This can include virtual tours of aircraft and airports, as well as immersive in-flight entertainment and other experiences (METAVERSE AVIATION: HOW AVIATION INDUSTRY CAN UTILIZE THE POTENTIAL OF METAVERSE?, 2023).

Focusing on the MRO part of the aerospace industry, some benefits of metaverse would be:

- Improving collaboration between remote teams:

Remote working has a negative impact on productivity when it comes to collaborations with other teams, customers or agents located abroad. Remote working enhances mental health working from a more comfortable, less fatigued environment (An et al., n.d.).

- Reduces travel time.
 - Reduces travel costs.
 - Reduces miscommunications between teams.
 - Meeting in real time with remote teams from the comfort of your home or office.
- Enhancement in training and education:

Training of technicians and mechanics on aircraft parts can become a hectic and long process. The parts need to be available as well as the technicians and trainers in real time. By creating virtual environments that simulate the experience of piloting an aircraft or operating complex machinery, pilots and engineers can gain valuable experience and skills without the risk associated with real-world training (Mystakidis 2022). This can be particularly valuable for military pilots, who may need to train for complex and dangerous missions without putting themselves or others at risk. A few benefits of training via the Metaverse are:

- Reduces costs of traditional training.
 - Reduces costs of providing aircraft parts.
 - Reduces any travel time and cost.
 - Enhances safety while working on aircraft.
- Supports remote inspections:

In case of any sudden repair of an aircraft, metaverse can assist in the mapping and diagnosis of the aircraft. This can help ensure the safety of technicians and minimize the repair time as the diagnosis can occur simultaneously during the travel (Wang, Tian, et al. 2022).

- Facilitate development and testing of new maintenance procedures:

The virtual development of prototypes helps in reducing time and cost associated with creating and building a physical prototype. One of the most promising applications of the metaverse in the aerospace industry is for research and development. By creating virtual simulations of aircraft, spacecraft, and other vehicles, researchers can conduct tests and experiments in a safe and controlled environment. This can help to accelerate the development process, as it allows engineers to iterate quickly and test new designs without the cost and risk associated with physical prototypes (Mystakidis 2022).

- Improving supply chain management:

The metaverse can aid the tracking and management of parts, equipment, and supplies in real-time. This reduces the risk of supply chain disruptions and improves supply chain efficiency (Chang, El-Rayes & Shi 2022).

- Safety:

In the metaverse, simulations of dangerous scenarios or situations can assist in testing of safety procedures and protocols. This can reduce the risk of actual accidents and incidents and enhance overall safety. Virtual simulations can also be used to model and simulate flight conditions, which can help to improve safety and efficiency in aviation (Mystakidis 2022). By analyzing flight data in the metaverse, researchers can identify potential issues or areas for improvement in aircraft design or flight procedures and test new solutions in a virtual environment before deploying them in the real-world (Mystakidis 2022).

- Maintenance planning:

Real-time data on the aircraft's status and equipment can be provided, which helps in controlling and maintaining the aircraft. This enhances the response time of the maintenance mechanics to any issues or problems while reducing downtime of the equipment and improving maintenance activity efficiency (Siyaev & Jo 2021b).

- Virtual training:

Metaverse can also be used to improve safety and efficiency in commercial aviation by providing virtual training. By using simulations to train pilots and crew members, airlines can ensure that their personnel are well-prepared for a range of scenarios, from routine flights to emergency situations. This can help to reduce the risk of accidents and improve the overall

safety of air travel (METAVERSE AVIATION: HOW AVIATION INDUSTRY CAN UTILIZE THE POTENTIAL OF METAVERSE?, 2023).

- Collaboration:

In addition to research, development, and training, the metaverse also has the potential to transform collaboration in the aerospace industry. By creating virtual environments that allow engineers, scientists, and other professionals to work together in real-time, regardless of their physical location, the metaverse can help to break down geographic barriers and improve communication and collaboration (Mystakidis 2022). This collaboration is not only beneficial to trainers and trainees, but it can also be utilized in other departments, including Project Management. An international project with many worldwide collaborations will require a lot of time and money wasted on travel. This will have a toll on the mental and physical capability of any person. With Metaverse in place, this collaboration can happen in real time from your own office.

This could be particularly valuable for international collaborations, where language barriers and cultural differences can make it difficult to work effectively. By using virtual environments to facilitate communication and collaboration, aerospace professionals can work together more effectively, sharing ideas and insights in real-time to accelerate progress and achieve better outcomes (Mystakidis 2022).

2.5.5 Challenges of Metaverse in Aerospace Industry:

Metaverse is currently a new concept in every industry excluding the gaming & entertainment industry. It is still being explored in the aviation industry. There are some challenges that come as major concerns whether to adopt such an innovation. These include:

1. The virtual simulations and virtual environment require significant computing resources; including advanced power and graphics processing, to run with no delays or interruptions. Aerospace companies will need to invest in high-end computing hardware or cloud-based solutions to support the metaverse initiatives.
2. The metaverse is a shared environment, robust security and data privacy protocols are required to protect sensitive information and intellectual property. It is highly important to make sure that access is limited to authorized users and that data is protected from theft.

Despite the requirements mentioned above, the Aerospace Industry is well on its way to taking advantage of the Metaverse's opportunities and benefits. The Aerospace Industry is always evolving and exploring the new frontiers in technological advancements. It takes advantage of the virtual collaboration, training and research and development. In the next section, a conceptual framework is built to support the literature review and data collection.

2.6 Conceptual Framework

2.6.1 Strategy

To start implementing any innovation within a company, especially something that can transform how a company functions, extensive research is mandatory. There are multiple frameworks or theories that examines the adoption of innovation, these include Technology Acceptance Model (TAM) (Davis 1989), Unified Theory of Acceptance and Use of Technology (UTAUT) (Arpaci et al. 2022), Diffusion of Innovation (DOI) (Rogers 2010), Theory of Planned Behavior (TPB) (Arpaci et al. 2022), and Technology-Organization-Environment (TOE) (Tornatzky & Fleischer 1990; Cho et al. 2022). In this paper, it revolves on the adoption of

metaverse in an organization as a unit and in the organizational level, the TOE Framework was the best approach. The independent variables were chosen based on the literature and following the TOE Framework. In the next subsections, the conceptual framework, hypothesis, and variables chosen will be broken down in detail.

2.6.2 Framework

The conceptual framework considers three main factors following the TOE Framework:

- Technological Factors
- Organizational Factors
- Environmental Factors

The TOE Framework was developed by (Tornatzky & Fleischer 1990). TOE focuses on the holistic approach of an organization as a unit. TOE provides a theoretical framework on the possibility and process of adopting technological innovation considering the pre-mentioned context/characteristics of an organization. Many research papers used TOE Framework to check to examine and evaluate the adoption of certain technological innovations; the adoption of Business Intelligence Systems in SMEs (Stjepić, Pejić Bach & Bosilj Vukšić 2021), the adoption of Customer Relationship Management, (Cruz-Jesus et al.), the use of Social Commerce in SMEs (Abed 2020), the implementation of e-government (Defitri et al. 2020) and much more. These studies support the valuable information that can be provided from the TOE Framework in the adoption of Metaverse in Aerospace Industries. Each factor is broken down in detail and examined thoroughly, then aligned with the metaverse and aerospace industry context to build a conceptual framework (Figure 4).

- Technological Characteristics:

The technological context refers to the technologies currently in use within the organization and ones that are found in the market but not yet adopted by the organization (Gutierrez, Boukrami & Lumsden 2015). In this paper, the technology referred to is Metaverse. The technological context includes the following factors:

1. Perceived Relative Advantage is used to determine the degree to which the new technology or innovation is perceived to be better than the existing technology currently being used (Vagnani & Volpe 2017). This gives an organization the information required for acquiring the new technology. It provides an indication of the probability of the technology adoption, which increases with the Perceived Relative Advantage. It focuses on different criteria, including the saving in cost, the enhancement in performance and the social desire/prestige. In the Aerospace Industry, the perceived advantage of using Metaverse would be considered in relation to the positive feedback from Airbus (Boyd & Koles 2019) in using VR to train future pilots. In addition, the embedding of AI in Boeing Aircraft (Siyayev & Jo 2021a) to support speech recognition for a cheaper Aircraft Maintenance Model. Therefore, the first hypothesis is formed:

H1: Perceived Relative Advantage positively influences the adoption of Metaverse.

2. Perceived Compatibility is used to determine the degree of compatibility of the new technology or innovation with the existing technology, processes, and culture of the organization as well as the current needs of an organization (Vagnani & Volpe 2017). Any change, whether small or drastic, within an organization is always met with resistance from the employees, so proper preparation and alignment with the organization structure is essential. The probability of adopting the new technology increases with the technological infrastructure compatibility in each organization (Jeon, Han & Lee 2006). In Aerospace

Industry, to properly adopt Metaverse, necessary requirements are essential to maintain the authenticity and support the robust nature of metaverse, refer to section 2.3. Therefore, the second hypothesis is formed:

H2: Perceived Compatibility positively influences the adoption of Metaverse.

3. Perceived Non-Complexity is used to determine the degree of new technology or innovation is perceived to being easy to understand and use (Vagnani & Volpe 2017). Metaverse's aim is to assist and simplify mode of business, the complexity with Metaverse will be during the implementation stage rather than the using stage. With the latest digitalization in this world, the use of Metaverse should not be difficult, especially for this and the next generations to come (Chua & Yu 2023). The probability of Metaverse adoption decreases with the increase in complexity (Thong 1999). Therefore, the third hypothesis is formed:

H3: Perceived Non-Complexity positively influences the adoption of Metaverse.

4. Perceived Trialability is used to determine the degree a new technology or innovation is easily used on a trial basis (Vagnani & Volpe 2017). This is similar to trying out clothes before purchasing, the probability that an organization will adopt a new technology with a complex technological infrastructure will increase with the potential trial period. Therefore, the fourth hypothesis is formed:

H4: Perceived Trialability positively influences the adoption of Metaverse.

5. Perceived Observability is used to determine the degree a new technology or innovation benefits can be easily seen and understood (*Rogers' Five Factors - How to Appraise Innovations* 2023). If the benefits of Metaverse can be seen right up front, then the probability of it being adopted increases significantly (Rogers 2002). In Aerospace

Industry, the adoption of new technologies is an ongoing process based on the benefits each innovation provides, in regards to Metaverse, the underlying techs that build up the metaverse are currently being used in the Aerospace Industry (Li et al. 2022). Therefore, the fifth hypothesis is formed:

H5: Perceived Observability positively influences the adoption of Metaverse.

6. Perceived Environmental Impact is used to determine the degree of new technology or innovation impact on the environment (Schmidt & Cummings 1976; Freel 2005). The positive or neutral impact on the environment will determine the acquiring of a new technology in addition to the organization culture. The countries are currently working together to protect and sustain the environment, if a new technology adoption can support an organization to decrease its environment impact, then this could benefit the organization in public relations and contributions towards its country (Colombo 2019; Phanden, Sharma & Dubey 2020; Dwivedi et al. 2022). Part of the aerospace industry is the research and creation of new aircraft that are considered more sustainable. Boeing is currently in collaboration with NASA to design a fuel efficient and low emission aircrafts (Strickland 2023). Therefore, the sixth hypothesis is formed:

H6: Perceived Environmental Impact positively influences the adoption of Metaverse.

- Organizational Characteristics:

The organizational context focuses on the organization's internal status such as size, structure, culture, and resources (Tornatzky & Fleischer 1990). The organizational context includes the following factors:

1. Perceived Top Management Support is used to determine the degree the employees believe the top management are in support of the new technology or innovation (Jeyaraj, Rottman & Lacity 2006). The culture of an organization has a huge impact on the adoption of metaverse, the culture is built by the top management within an organization, they will provide the vision and values that an organization follows (Hsu et al. 2019a). Therefore, the seventh hypothesis is formed:

H7: Perceived Top Management positively influences the adoption of Metaverse.

2. Perceived Organizational Readiness is used to determine the degree an organization is ready to implement a new technology or innovation. This is determined by asking the employees perception on the culture, resources, and leadership of the organization (Chircu & Kauffman 2000). This includes the training, implementation, awareness, and culture to adopt a new technology. The Aerospace Industry is dynamic but requires a specific type of readiness to officially adopt Metaverse (*Aerospace and Defense Technology Vision 2022* 2022). Therefore, the eight hypothesis is formed:

H8: Perceived Organizational Readiness positively influences the adoption of Metaverse.

3. Perceived Organizational Needs is used to determine the requirements or the needs of an organization to implement a new technology or innovation to meet the employees' needs (Allen et al. 2008). With the adoption of Metaverse, it can help in enhancing the work-life balance of an organization's employees. Metaverse can support remote working and less work travel, enhance the safety and training of each employee (Mystakidis 2022). Therefore, the ninth hypothesis is formed:

H9: Perceived Organizational Needs positively influence the adoption of Metaverse.

4. Perceived Employee Pressure is to determine the degree to which employees feel pressure in an organization from its environment (Allen et al. 2008). It can be measured by an organization's atmosphere and culture on the employees, as well as the workload and submissions. The adoption of metaverse can support the positive mental stability of an employee. Therefore, the tenth hypothesis is formed:

H10: Perceived Employee Pressure positively influences the adoption of Metaverse.

- Environmental Characteristics:

The environmental context focuses on the external factors that have an effect on the adoption of new technologies or innovation, including industry, competitors, government, and resources (Tornatzky & Fleischer 1990). The environmental context includes the following factors:

1. Perceived Competitive Pressure is used to determine the degree to which an organization believes that other organizations are using the new technology or innovation to gain competitive advantage (Soto-Acosta, Popa & Palacios-Marqués 2016). This competition between organizations increases the percentage and probability of adopting innovations. Currently in the Aerospace Industry, the competition lies in several categories, being safest airlines, cost-efficient in aviation, most sustainable aircrafts, most innovative aircrafts, caters to high end businesses and much more (Borgogna, Bejjani & Khalifa 2017; Oliveira & Oliveira 2018). Therefore, the eleventh hypothesis is formed:

H11: Perceived Competitive Pressure positively influences the adoption of Metaverse.

2. Perceived Governmental Support is used to determine the degree to which an organization believes that the government is supportive to its ability to implement and adopt new technologies (Gibbs & Kraemer 2004). This could include the support by providing

incentives when adopting new technologies. In the Aerospace Industry, everything is highly regulated by multiple entities worldwide, the support of the government to Metaverse can guide the entities to research and regulate the use of metaverse (Holland 2022). Therefore, the twelfth hypothesis is formed:

H12: Perceived Governmental Support positively influences the adoption of Metaverse.

3. Perceived Supply Chain Pressure is used to determine the degree of the demands of an organization supplier and customers' (Sila 2013). The influence of the suppliers and customers on an organization through persuasion or threats can increase the probability of Metaverse Adoption. In the case of Boeing or Airbus, they are investigating the potential of using the virtual reality in aviation (*Virtual reality* 2016; Ulukan 2021). Therefore, the thirteenth hypothesis is formed:

H13: Perceived Supply Chain Pressure positively influences the adoption of Metaverse.

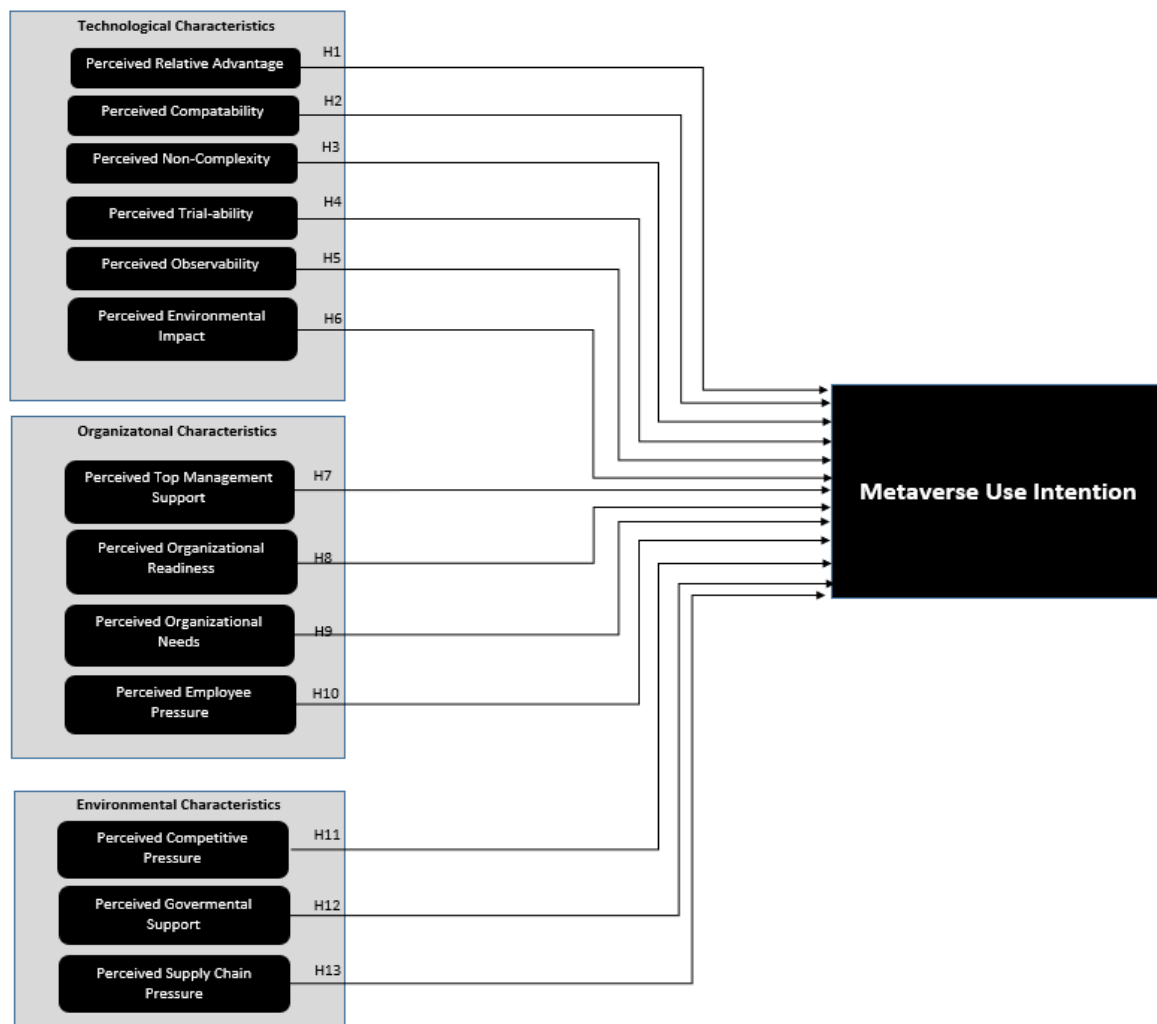


Figure 2-7: The Conceptual Framework.

2.7 Chapter Summary

This chapter initially provided a detailed description of what metaverse is along with its foundation. It then provided detailed descriptions of the Aerospace Industry innovations and challenges and benefits of the implementation of the metaverse in the industry. As an overall view, metaverse provides a virtual environment that incorporates the physical world along with virtual aspects. It will be available for everyone to use in their personal and professional lives.

The metaverse, if implemented in the Aerospace Industry, can support sustainability, financial aspects and enhance the industry's efficiency. Later on, the conceptual framework is developed around the literature review. The conceptual framework adapted the TOE Framework as the focus is on an organizational level. 13 Hypotheses were developed. The next chapter will go into depth on the research methodology adopted and the analysis processes of the data gathered.

Chapter 3: Research Methodology

3.1 Introduction

In this chapter, the research methodology and approach of the paper is defined, along with the philosophy of the paper. The strategy used is also outlined in detail. The construct of the questionnaire is also provided along with the supporting papers on all the independent and dependent variables considered. The pilot study, data collection and data analysis are also defined, and its process is shared.

3.2 Research Approach

Research has different ways to construct the paper. Two of the most commonly used ones are: the inductive and deductive approaches. The inductive approach focuses on a bottom-to-top approach, where data gathering, and observations come first then a hypothesis is formulated (Soiferman 2010). Deductive approach follows the opposite path, where a hypothesis is formulated, then data is gathered and analyzed to either accept or refute the hypothesis. It supports the gathering of data from a specific niche of people to then generalize to the people with similar aspects (Soiferman 2010).

The aim of this paper is mainly to determine the potential and position of adopting Metaverse in the Aerospace Industry at an organizational level. As shown below in figure 5, a positivist ontological stance is assumed, where the reality is objective and independent and can be understood and supported by scientific evidence (Ryan 2018). In addition, the research study is following epistemologically deductive research. This is supported by the fact that the factors influencing the adoption of metaverse in aerospace are identified and the relationship between

the independent and dependent variables are established by reviewing the literature and development of hypotheses. These hypotheses are then tested by gathering empirical data sets and analyzing the data to either accept or refute the hypothesis (Ryan 2018). The independent and dependent variables are numerically measured and the relationship between them is assessed through a statistical data analysis after gathering of data by quantitative methods, questionnaire.

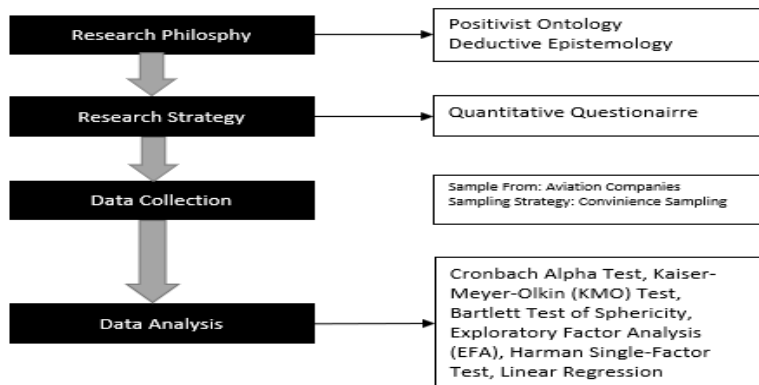


Figure 3-1: Methodology Flow Chart.

3.3 Research Strategy

There are limited studies reported in the literature that have attempted to study metaverse in Aerospace Industry. The focus of this study is to help improve metaverse adoption and implementation, by studying factors at an organizational level that can contribute to effectiveness of the adoption.

The data gathering for the study is divided into three systematic connected stages. The first stage of the research involves an intensive literature review of defining metaverse, its architecture and

features. The second stage of the research involves detailed information on the benefits of the new innovative technologies for the aerospace industry.

In the third stage, a questionnaire is developed based on organizational, technological, and environmental factors that have direct influence on an organization perception towards metaverse. The questionnaire was answered by multiple Aviation Companies Worldwide (see Appendix 1). Questions within the survey are linked to the factors, with each question supported by evidence reported in the literature.

3.4 Methodology

Research methodology consists of the method used to gather data for analysis to either support or refute the pre-mentioned hypotheses. The methodology used is quantitative method. This entails the collection of data using surveys and/or questionnaires. The data is assigned a numerical variable that assists with the analysis, thus generating a result that can be generalized to targeted audience. The questionnaire consisted of 31 questions with interval variables of the five-point Likert scale. Table 2 below lists the main constructs and their measurement items. Additional data was collected focusing on the organization's type, size and location, as well as the participants' demographics, age, education, experience, title and focus.

Table 2: Construct and Measurement Items.

Construct	Measurement Items	Source
PART II: Technological Characteristics		
Part II.A: Perceived Relative Advantage		
PRA1	Metaverse reduces travel time.	

PRA2	Metaverse reduces travel costs using VR/AR/XR technologies.	(Patel & Connolly
PRA3	Metaverse reduces cost for virtual knowledge sharing and networking using VR/AR/XR technologies.	2007; Madni, Madni &
PRA4	Metaverse reduces cost for Virtual conferences and events using VR/AR/XR technologies.	Lucero 2019; Kye et al.
PRA5	Metaverse reduces cost for training using VR/AR/XR technologies.	2021; Siyaev & Jo 2021a;
PRA6	Metaverse reduce cost for remote maintenance and troubleshooting.	Dwivedi et al. 2022; Lawton
PRA7	Metaverse reduces costs through collaborative design and prototyping. (For example, real-time collaboration of aerospace engineers and designers across the globe).	2022; Wang, Wang, et al. 2022; Yang et
PRA8	Metaverse reduces the use of physical materials using digital twin technology. (For example, creating virtual prototypes rather than physical ones)	al. 2022; Mourtzis, Angelopoulos &
PRA9	Metaverse enhances data security through decentralized Blockchain platforms.	Panopoulos 2023; O'Conner 2023)

Part II.B: Perceived Compatibility

PC1	Metaverse is compatible with the technological needs in my organization.	(Patel & Connolly 2007; Lawton 2022;
PC2	Metaverse is consistent with the existing values and beliefs of my organization.	Mourtzis et al. 2022b; Khan et al. 2023)

Part II.C: Perceived Non-Complexity

PNC1	Metaverse is easy to understand.	(Khan et al., 2023;
PNC2	Metaverse is easy to manage and use.	
PNC3	Metaverse is easy to integrate with existing processes and current technologies in my organization.	Lawton, 2022; Patel & Connolly, 2007; Rawat & alami, 2023)
PNC4	Metaverse is scalable.	

Part II.D: Perceived Trial-ability

PTA1	Our organization has the chance to experiment with the Metaverse before completely adopting it.	(Patel & Connolly
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PTA2	Our organization places a high priority on trial-ability when deciding whether to employ cutting-edge technology like the metaverse.	2007; Akour et al. 2022; Bobier et al.
PTA3	Our organization has access to the necessary resources and support to trial the Metaverse.	2022)

Part II.E: Perceived Observability

PO1	It is easy to see and well-documented how the Metaverse (digital twins) has benefited the aerospace sector.	(Patel &
PO2	Our organization is aware of successful Metaverse (digital twins) installations at other aerospace companies.	Connolly
PO3	The aerospace sector has a history of getting quantifiable benefits from the Metaverse.	2007; Phanden,
PO4	Our organization has access to trustworthy data on how the Metaverse affects the aerospace industry productivity, cost, and safety.	Sharma & Dubey 2020)

Part II.F: Perceived Environmental Impact

PEI1	My organization can reduce its environmental impact by embracing the Metaverse.	(Colombo 2019;
PEI2	My organization can reduce waste and improve sustainability by using the Metaverse.	Phanden, Sharma &
PEI3	The Metaverse's adoption by my organization is in line with international initiatives to fight climate change and advance environmental sustainability.	Dubey 2020; Dwivedi et al. 2022)

PEI4	My organization acknowledges the Metaverse as a tool for lessening the need for actual travel and, thus, reducing greenhouse gas emissions.
PEI5	My organization can use the Metaverse to bring more eco-friendly methods to the aerospace sector.
PEI6	Adopting Metaverse will increase technological waste (e-waste) in the form of electronic parts or equipment.
PEI7	Adopting Metaverse will increase environmental waste (e.g., CO2).
PEI8	My organization's efforts to be more environmentally friendly could benefit from Metaverse.

PART III: Organizational characteristics

Part III.A: Perceived Top Management Support

PTMS1	Top management in my organization is aware of the benefits that metaverse can provide.	(Phanden, Sharma &
PTMS2	Our organization has well defined objectives and plans to implement Metaverse in the aerospace sector.	Dubey 2020; Lee et al.
PTMS3	The management of our organization is flexible and encourages the investigation of novel technologies, such the Metaverse.	2021; Haque et al. 2022; Xu et al.
PTMS4	Our organization continually reviews and modifies its technological foundation to support new developments like the Metaverse.	2022; Yawised, Apasrawirote

PTMS5	Top management in my organization fully supports the adoption of Metaverse.	& Boonparn 2022;
PTMS6	Our organization is prepared to make any relevant future investments in metaverse to support it as a top priority.	Queiroz et al. 2023)

Part III.B: Perceived Organizational Readiness

	To help the adoption of cutting-edge technologies like the Metaverse, our organization is dedicated to lifelong learning and skill development.	(Cheng et al. 2022;
POR1		
POR2	The decision-makers in my organization are aware of the potential opportunities and risks of the Metaverse.	Nguyen, Lee & Verma 2022; Park &
POR3	My organization will need additional staff with Metaverse skills to run and develop Metaverse applications.	Kim 2022; Tando &
POR4	My organization will need external support in legal complexities regarding the Metaverse.	Adillah 2022; Hastuti,
POR5	My organization will need external support in business management in regard to the Metaverse.	Sanjaya & Koeswoyo 2023)
POR6	My organization will need external support in technical capabilities with regards to the Metaverse.	

Part III.C: Perceived Organizational Needs

PON1	Our organization has a very clear need for the Metaverse to boost its efficiency and effectiveness.	(What is the metaverse?
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		2017; Ibrion, Paltrinieri & Nejad 2019;
PON2	Our organization is aware of the necessity to embrace the Metaverse (Digital Twins) in order to stay up to date with the aerospace industry's innovations in technology.	Bobier et al. 2022; Lawton 2022; Li et al. 2022; Mourtzis et al. 2022b)

Part III.D: Perceived Employee Pressure

PEF1	Our organization's employees have shown interest in exploiting (exploring) the Metaverse for numerous aviation applications.	
PEF2	The introduction of the Metaverse in our company will be decided after considering employee feedback.	(Lee et al.
PEF3	The majority of the employees at our organization believe that exploring the Metaverse can boost productivity and efficiency.	2021; Bobier et al. 2022; Xi et al. 2022)
PEF4	The Metaverse, in the opinion of our employees, has the potential to improve teamwork and communication.	
PEF5	Our organization values feedback from staff and considers it while developing and implementing the Metaverse.	

PART IV: Environmental Characteristics

Part IV.A: Perceived Competitive Pressure

PCP1	Our competitors have embraced the Metaverse (digitalization) largely, which puts pressure on our company to do the same.	(The Metaverse Overview: Vision, Technology, and Tactics 2022;
PCP2	The fact that the Metaverse (digitalization) is adopted quickly by the aerospace sector, which puts more pressure on our organization to compete.	Garneau, Pérez-Lauzon & Lévesque 2023)
PCP3	According to our organization, the Metaverse is a crucial instrument for addressing the aerospace industry's rising competitive needs.	
PCP4	The use of Metaverse will allow the generation of new revenue streams for my organization.	

Part IV.B: Perceived Government Support

PGS1	Government legislation supports the adoption of Metaverse technology.	(Hastuti, Sanjaya & Koeswoyo 2023; Kshetri 2023)
PGS2	Legislation about Metaverse technology is transparent.	
PGS3	Firms are legally protected when using Metaverse technology.	

Part IV.C: Perceived Supply Chain Pressure

PSCP1	My organization's suppliers recommend the adoption of Metaverse technology.	(Queiroz et al. 2023)
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PSCP2 My organization's customers have requested the adoption
of Metaverse technology.

PART V: Metaverse Use Intention

MUI1	Future operations and tactics for my organization will heavily rely on the Metaverse.	(Almarzouqi,
MUI2	My organization intends to use metaverse actively.	Aburayya &
MUI3	My organization intends to use the Metaverse in collaboration with suppliers.	Salloum 2022; Hastuti,
MUI4	My organization will be utilizing Metaverse technology in aerospace-related operations and activities.	Sanjaya & Koeswoyo
MUI5	My organization intends to recommend Metaverse technology to others.	2023)

*Respondents were asked to rate the extent to which they agree or disagree with the statements above. All responses were measured on the 5-point Likert-Scale where 1= Strongly Agree, 2= Agree, 3= Neither Agree nor Disagree, 4=Disagree, 5=Strongly Disagree.

3.5 Pilot Study

A pilot study was conducted to assess the feasibility and accuracy of using a questionnaire to collect data on the use of metaverse by aerospace organizations and to validate the content. The pilot evaluation was performed by forwarding the questionnaire using convenience sampling to 5 aerospace employees and 3 research professionals who completed the questionnaire. This pilot participant shared their feedback on the length, time taken and understanding of the questionnaire. The questionnaire was therefore adjusted as per the feedback, removing repetitive

questions as well as adjusting the construction it. Afterwards, it was decided to proceed with the larger study.

3.6 Data Collection

This research study adopted the approach of convenience sampling with the focus on approaching different Aviation or Aerospace related companies or expertise. The questionnaire was designed and developed through an online questionnaire website; questionpro.com. Afterwards, the questionnaire was shared on online platforms, i.e., LinkedIn. It was also shared via email to multiple Aviation professionals and companies. To maintain authenticity of the data and the proper selection of participants, there was a pre-qualification process that was managed by the first question in the questionnaire. This question made sure only qualified participants who knew about metaverse could proceed with the questionnaire response. The data collection took place over 3 weeks from May 14th, 2023, to June 7th, 2023. The final database consisted of 61 questionnaire responses, broken down into:

- 323 Views
- 61 Responses
- 33 Incomplete Responses
- 14 Terminated from Pre-Qualification Question.
- 28 Complete Responses

3.7 Data Analysis

Measures were taken to make sure of the reliability and validity of the constructs using the data analysis tool IBM SPSS Statistics Software. Reliability of the construct means that the

questionnaire has an internal consistency throughout, where the correlation of each answer with the answers by the same participant in the same questionnaire (Singh 2017). The validity of the construct means that the questionnaire used is measuring what is really required mainly the constructs and variables mentioned in table 2 (Singh 2017).

To check the reliability of the questionnaire, the data was introduced for a Cronbach's Alpha Test to check for the reliability of the construct (Tavakol & Dennick 2011), the Kaiser-Meyer-Olkin (KMO) Test to check the correlations between variables individually (Kaiser 1974), and the Bartlett Test of Sphericity to check the correlations' occurrences (Ul Hadia, Abdullah & Sentosa 2016). To check the validity of the data, it was introduced to the Exploratory Factor Analysis (EFA) with the utilization of the Principal Components Analysis and the Varimax Rotation Method to extract the constructs (Ul Hadia, Abdullah & Sentosa 2016). Lastly, Harman Single-Factor Test to perform a common method bias (Fuller et al. 2016a).

3.8 Chapter Summary

This chapter defined the research methodology adapted by the paper. Focusing on the construct of the questionnaire around the independent and dependent variables. The research adapted a positivist ontology with a deductive epistemology, using quantitative method to gather data. The sample selection was based on convenience. The analysis of data will be performed over IBM SPSS Statistics Software, focusing on reliability and validity test as shown in the next chapter.

Chapter 4: Findings and Data Analysis

4.1 Introduction

In this chapter, the collected data analysis takes place using the SPSS Statistics Tool. Reliability and Validity Tests are performed. The data collected from the questionnaire are also outlined below. In addition, a discussion takes place to further analyze the tables generated from SPSS.

4.2 Demographics Data

The data sample from the demographics focused more on the Maintenance, Repair and Overhaul sector, but was fairly distributed through the different professions as shown below in table 3.

Table 3: Participants' Demographics

Characteristics	Respondents (Number)	Respondents Percentage of Total (%)
<i>Organizational Type:</i>		
Manufacturing	1	3.13
Maintenance, Repair & Overhaul	29	90.63
Service Providers	1	3.13
Others, Investors	1	3.13
<i>Organizational Size:</i>		
1-49	1	3.13
50-249	25	78.13

5,000-more	6	18.75
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Organization Location:

Germany	4	12.5
United Arab Emirates	27	84.38
United Kingdom	1	3.13

Participants Age:

19-24	3	9.38
25-34	19	59.38
35-44	7	21.88
45-54	3	9.38

Participants Educational Level:

Technical or Vocational Training	1	3.13
Bachelor's Degree	21	65.63
Master's Degree	10	31.25

Participants Work Experience:

0-5 Years	13	40.63
6-10 Years	9	28.13
11-15 Years	4	12.5
16-19 Years	2	6.25
+20 Years	4	12.5

Participants Department:

Supply Chain Management	6	18.75
Finance	2	6.25

Human Resources	2	6.25
Executive	2	6.25
Marketing	2	6.25
Operations	6	18.75
Others, Sales	7	21.88
Others, Project Management	2	6.25
Others, Customer Service	1	3.13
Others, Engineering	2	6.25
<i>Participants Job Title:</i>		
Administrative or Support Staff	2	6.25
Professional or Technical Staff	8	25
Manager or Supervisor	15	46.88
Vice President or Director	2	6.25
CEO, President, or Owner	1	3.13
Others, Sales & Account Manager	2	6.25
Others, Coordinator	2	6.25

4.3 Validity and Reliability Tests

4.3.1 Cronbach's Alpha Test

The results of the Cronbach's Alpha Test are evaluated using (Tavakol & Dennick 2011). The constructs were found to be ranging between 0.6 and 1.0 as shown in Table 4.

Table 4: Cronbach's α score for each factor of the technology-organization-environment (TOE) framework.

The Variables	Number of Items	Cronbach's Alpha
Perceived Relative Advantage	9	0.902
Perceived Compatibility	2	0.680
Perceived Non-Complexity	4	0.794
Perceived Trial-ability	3	0.722
Perceived Observability	4	0.913
Perceived Environmental Impact	8	0.896
Perceived Top Management Support	6	0.903
Perceived Organizational Readiness	6	0.914
Perceived Organizational Needs	2	0.806
Perceived Employee Pressure	5	0.891
Perceived Competitive Pressure	4	0.851
Perceived Governmental Support	3	0.893
Perceived Supply Chain Pressure	2	0.816
Metaverse Use Intention	5	0.918

4.3.2 Kaiser-Meyer-Olken Test

According to Kaiser (1974), the factor from the KMO depicted in table 5 should be above 0.500 to be acceptable. The KMO scores analyzed from the collected data were either at 0.500 or above.

Table 5: Kaiser-Meyer-Olkin (KMO) Test and Bartlett Test of Sphericity.

The Variables	Kaiser-Meyer-Olkin (KMO)	Bartlett's Test of Sphericity
Perceived Relative Advantage	0.848	<0.001
Perceived Compatibility	0.500	0.003
Perceived Non-Complexity	0.749	<0.001
Perceived Trial-ability	0.639	<0.001
Perceived Observability	0.810	<0.001
Perceived Environmental Impact	0.842	<0.001
Perceived Top Management Support	0.894	<0.001
Perceived Organizational Readiness	0.868	<0.001
Perceived Organizational Needs	0.500	<0.001
Perceived Employee Pressure	0.685	<0.001
Perceived Competitive Pressure	0.755	<0.001
Perceived Governmental Support	0.716	<0.001
Perceived Supply Chain Pressure	0.500	<0.001
Metaverse Use Intention	0.881	<0.001

4.3.3 Linear Regression Analysis Test

To analyze the data gathered and verify the hypotheses, IBM SPSS Program was used to perform a linear regression analysis test. This test helps determine the level of significance of any relation found between the variables against the Metaverse Use Intention. This will help to identify which factors directly affect the use of metaverse in the Aerospace Industry.

The regression analysis results are shown in the tables 6 and 7 below. Table 6 shows that the independent variables, b, have a high effect in predicting the dependent variable, MUI.

Table 6: Regression Model ANOVA.

ANOVA ^a					
Model 1	Sum of Squares	df	Mean Square	F	Sig.
Regression	13.52	13	1.04	8.34	<.001 ^b
Residual	1.995	16	0.125		
Total	15.515	29			

a. Dependent Variables: MUI

b. Predictors: (Constant), PSCP_Combine, PT_Combine, PEP_Combine, PON_Combine, PNC_Combine, PC_Combine, PCP_Combine, PGS_Combine, PRA_Combine, POR_Combine, PO_Combine, PTMS_Combine, PEI_Combine

Table 7: Regression Model Coefficient.

Coefficients ^a										
Model 1	Unstan dardiz ed B	Coeffi cients Std. Error	Standardized Coefficients Beta	t	Sig.	95% Confidence Interval for B		Correlations		
						Lower Bound	Upper Bound	Zero- order	Partials	Tolera nce
(Constant)	0.562	0.303		1.857	0.082	-0.08	1.204			
PRA	0.041	0.267	0.041	0.154	0.879	-0.525	0.607	0.698	0.039	0.113
PC	0.159	0.149	0.194	1.066	0.302	-0.157	0.476	0.776	0.257	0.243
PNC	0.005	0.189	0.006	0.029	0.977	-0.395	0.406	0.659	0.007	0.204
PT	0.013	0.121	0.016	0.106	0.917	-0.243	0.269	0.544	0.026	0.37
PO	-0.012	0.198	-0.014	-0.061	0.952	-0.431	0.407	0.735	-0.015	0.155
PEI	-0.255	0.265	-0.242	-0.961	0.351	-0.816	0.307	0.607	-0.234	0.126
PTMS	0.283	0.219	0.312	1.295	0.214	-0.181	0.748	0.838	0.308	0.139
POR	0.203	0.209	0.208	0.969	0.347	-0.241	0.647	0.718	0.235	0.175
PON	-0.048	0.12	-0.058	-0.403	0.692	-0.303	0.206	0.626	-0.1	0.383
PEP	-0.005	0.182	-0.005	-0.025	0.98	-0.391	0.382	0.664	-0.006	0.211
PCP	0.076	0.195	0.084	0.392	0.7	-0.336	0.489	0.78	0.098	0.177
PGS	0.236	0.148	0.288	1.593	0.131	-0.078	0.55	0.828	0.37	0.245
PSCP	0.15	0.12	0.208	1.244	0.232	-0.105	0.405	0.784	0.297	0.288
a. Dependent Variable: MUI										

Table 7 shows the collinearity test results and the estimated coefficients and statistics for each predictor used in the ANOVA Model. In addition, it provides the Variance Inflation Factor (VIF) for each predictor and its significance (p-value) on the MUI.

Table 8: Descriptive Statistics.

Item Number	Item Questions	Participants Answer Percentage (%)				
		SA	A	N	DA	SDA
PRA1	Metaverse reduces travel time.	18.75%	43.75%	28.12%	6.25%	3.12%
PRA2	Metaverse reduces travel costs using VR/AR/XR technologies.	28.12%	56.25%	12.5%	0%	3.12%
PRA3	Metaverse reduces cost for virtual knowledge sharing and networking using VR/AR/XR technologies.	25%	46.88%	15.62%	9.38%	3.12%
PRA4	Metaverse reduces cost for Virtual conferences and events using VR/AR/XR technologies.	18.75%	46.88%	21.88%	9.38%	3.12%
PRA5	Metaverse reduces cost for training using VR/AR/XR technologies.	25%	53.12%	15.62%	3.12%	3.12%
PRA6	Metaverse reduce cost for remote maintenance and troubleshooting.	6.25%	37.5%	37.5%	15.62%	3.12%
PRA7	Metaverse reduces costs through collaborative design and prototyping.	15.62%	50%	31.25%	0%	3.12%
PRA8	Metaverse reduces the use of physical materials using digital twin technology.	25%	43.75%	18.75%	9.38%	3.12%

	(For example, creating virtual prototypes rather than physical ones)					
PRA9	Metaverse enhances data security through decentralized Blockchain platforms.	21.88%	28.12%	37.5%	6.25%	6.25%
PC1	Metaverse is compatible with the technological needs in my organization.	6.25%	25%	40.62%	21.88%	6.25%
PC2	Metaverse is consistent with the existing values and beliefs of my organization.	3.12%	37.5%	31.25%	21.88%	6.25%
PNC1	Metaverse is easy to understand.	9.38%	25%	40.62%	15.62%	9.38%
PNC2	Metaverse is easy to manage and use.	3.12%	28.12%	46.88%	12.5%	9.38%
PNC3	Metaverse is easy to integrate with existing processes and current technologies in my organization.	3.12%	6.25%	53.12%	21.88%	15.62%
PNC4	Metaverse is scalable.	18.75%	34.38%	43.75%	0%	3.12%
PTA1	Our organization has the chance to experiment with the Metaverse before completely adopting it.	6.25%	40.62%	37.5%	6.25%	9.38%
PTA2	Our organization places a high priority on trial-ability when deciding whether to employ cutting-edge technology like the metaverse.	18.75%	40.62%	18.75%	15.62%	6.25%
PTA3	Our organization has access to the necessary resources and support to trial the Metaverse.	3.12%	28.12%	28.12%	31.25%	9.38%

PO1	It is easy to see and well-documented how the Metaverse (digital twins) has benefited the aerospace sector.	3.12%	43.75%	37.5%	12.5%	3.12%
PO2	Our organization is aware of successful Metaverse (digital twins) installations at other aerospace companies.	6.25%	28.12%	37.5%	21.88%	6.25%
PO3	The aerospace sector has a history of getting quantifiable benefits from the Metaverse.	3.12%	28.12%	50%	12.5%	6.25%
PO4	Our organization has access to trustworthy data on how the Metaverse affects the aerospace industry productivity, cost, and safety.	3.12%	28.12%	43.75%	18.75%	6.25%
PEI1	My organization can reduce its environmental impact by embracing the Metaverse.	12.5%	56.25%	15.62%	12.5%	3.12%
PEI2	My organization can reduce waste and improve sustainability by using the Metaverse.	15.62%	53.12%	25%	3.12%	3.12%
PEI3	The Metaverse's adoption by my organization is in line with international initiatives to fight climate change and advance environmental sustainability.	9.38%	37.5%	40.62%	9.38%	3.12%
PEI4	My organization acknowledges the Metaverse as a tool for lessening the need	9.38%	50%	28.12%	9.38%	3.12%

	for actual travel and, thus, reducing greenhouse gas emissions.					
PEI5	My organization can use the Metaverse to bring more eco-friendly methods to the aerospace sector.	9.38%	71.88%	15.62%	0%	3.12%
PEI6	Adopting Metaverse will increase technological waste (e-waste) in the form of electronic parts or equipment.	3.12%	28.12%	53.12%	12.5%	3.12%
PEI7	Adopting Metaverse will increase environmental waste (e.g., CO2).	6.25%	31.25%	37.5%	18.75%	6.25%
PEI8	My organization's efforts to be more environmentally friendly could benefit from Metaverse.	6.25%	59.38%	31.25%	0%	3.12%
PTMS1	Top management in my organization is aware of the benefits that metaverse can provide.	3.33%	36.67%	36.67%	20%	3.33%
PTMS2	Our organization has well defined objectives and plans to implement Metaverse in the aerospace sector.	3.33%	20%	36.67%	33.33%	6.67%
PTMS3	The management of our organization is flexible and encourages the investigation of novel technologies, such the Metaverse.	13.33%	53.33%	23.33%	6.67%	3.33%
PTMS4	Our organization continually reviews and modifies its technological foundation to	13.33%	40%	23.33%	16.67%	6.67%

	support new developments like the Metaverse.					
PTMS5	Top management in my organization fully supports the adoption of Metaverse.	6.67%	20%	53.33%	16.67%	3.33%
PTMS6	Our organization is prepared to make any relevant future investments in metaverse to support it as a top priority.	10%	13.33%	43.33%	26.67%	6.67%
POR1	To help the adoption of cutting-edge technologies like the Metaverse, our organization is dedicated to lifelong learning and skill development.	10%	50%	26.67%	10%	3.33%
POR2	The decision-makers in my organization are aware of the potential opportunities and risks of the Metaverse.	3.33%	30%	56.67%	6.67%	3.33%
POR3	My organization will need additional staff with Metaverse skills to run and develop Metaverse applications.	33.33%	40%	23.33%	0%	3.33%
POR4	My organization will need external support in legal complexities regarding the Metaverse.	13.33%	60%	20%	3.33%	3.33%
POR5	My organization will need external support in business management in regard to the Metaverse.	16.67%	53.33%	23.33%	3.33%	3.33%

POR6	My organization will need external support in technical capabilities with regards to the Metaverse.	30%	40%	26.67%	0%	3.33%
PON1	Our organization has a very clear need for the Metaverse to boost its efficiency and effectiveness.	3.33%	16.67%	36.67%	36.67%	6.67%
PON2	Our organization is aware of the necessity to embrace the Metaverse (Digital Twins) in order to stay up to date with the aerospace industry's innovations in technology.	10%	30%	40%	16.67%	3.33%
PEF1	Our organization's employees have shown interest in exploiting (exploring) the Metaverse for numerous aviation applications.	6.67%	36.67%	33.33%	16.67%	6.67%
PEF2	The introduction of the Metaverse in our company will be decided after considering employee feedback.	6.67%	40%	36.67%	13.33%	3.33%
PEF3	The majority of the employees at our organization believe that exploring the Metaverse can boost productivity and efficiency.	6.67%	16.67%	53.33%	20%	3.33%
PEF4	The Metaverse, in the opinion of our employees, has the potential to improve teamwork and communication.	3.33%	43.33%	43.33%	6.67%	3.33%

PEF5	Our organization values feedback from staff and considers it while developing and implementing the Metaverse.	23.33%	36.67%	30%	6.67%	3.33%
PCP1	Our competitors have embraced the Metaverse (digitalization) largely, which puts pressure on our company to do the same.	3.33%	20%	50%	20%	6.67%
PCP2	The fact that the Metaverse (digitalization) is adopted quickly by the aerospace sector, which puts more pressure on our organization to compete.	13.33%	36.67%	30%	13.33%	6.67%
PCP3	According to our organization, the Metaverse is a crucial instrument for addressing the aerospace industry's rising competitive needs.	6.67%	26.67%	46.67%	16.67%	3.33%
PCP4	The use of Metaverse will allow the generation of new revenue streams for my organization.	16.67%	43.33%	33.33%	3.33%	3.33%
PGS1	Government legislation supports the adoption of Metaverse technology.	13.33%	40%	43.33%	0%	3.33%
PGS2	Legislation about Metaverse technology is transparent.	16.67%	10%	50%	16.67%	6.67%
PGS3	Firms are legally protected when using Metaverse technology.	6.67%	20%	56.67%	6.67%	10%

PSCP1	My organization's suppliers recommend the adoption of Metaverse technology.	6.67%	13.33%	40%	30%	10%
PSCP2	My organization's customers have requested the adoption of Metaverse technology.	6.67%	20%	33.33%	23.33%	16.67%
MUI1	Future operations and tactics for my organization will heavily rely on the Metaverse.	3.33%	30%	40%	20%	6.67%
MUI2	My organization intends to use metaverse actively.	0%	20%	56.67%	20%	3.33%
MUI3	My organization intends to use the Metaverse in collaboration with suppliers.	0%	23.33%	50%	23.33%	3.33%
MUI4	My organization will be utilizing Metaverse technology in aerospace-related operations and activities.	6.67%	33.33%	46.67%	10%	3.33%
MUI5	My organization intends to recommend Metaverse technology to others.	6.67%	13.33%	63.33%	13.33%	3.33%

Table 8 shows the frequency of the responses of the participants to the questionnaire variables.

4.4 Chapter Conclusion

This chapter used SPSS to validate and check the reliability of the data collected. Multiple tables were generated and further analyzed. The data gathered will be further analyzed in the next chapter.

Chapter 5: Conclusion

5.1 Research Discussion

The survey was conducted online and sent to multiple Aviation companies as well as placed on LinkedIn Pages. The survey received 61 responses, with 33 incompletes, 14 terminated by the first question and 28 complete responses. The data was analyzed by IBM SPSS and the overview of the results can be found below.

Table 9: Overview of Results.

Analysis Performed	Results	Description	Table number
The Cronbach's Alpha Value (α-score)	>0.6	Reliable & Valid	Table 4
Kaiser-Meyer-Olken Test (KMO)	>=0.5	Reliable	Table 5
Bartlett's Test of Sphericity	<0.003	Reject null hypothesis	Table 5
Exploratory Factor Analysis (EFA)	Eigenvalue >1	Valid	--
Harmen Single-Factor Test	Data Variance >50%	Common Method Bias found	--
ANOVA	Sig<0.001	Independent variables* have an effect on dependent variable**	Table 6

Variance Inflation Factor (VIF)	<10	No unapparent multicollinearity problems	Table 7
Regression significance	>0.05	No statistical significance of independent variables	Table 7

*PSCP, PT, PEP, PON, PNC, PC, PCP, PGS, PRA, POR, PO, PTMS, PEI

**MUI

To start interpreting the data, internal consistency and reliability are initially examined using the scores of 28 completed responses to the questionnaire and disregarding any incomplete responses. The table 9 above, shows the overview of the results. To further interpret the results, Cronbach's alpha (Tavakol & Dennick 2011) suggests that the variables are dependable, reliable, and valid. Proving the consistency and accuracy of the measure in this study. The KMO scores were either at 0.500 or above, once again confirming the reliability of the data and accepting the variables for further analysis according to Kaiser (1974). To additionally validate the data, Exploratory Factor Analysis (EFA) was initiated. The EFA test utilized Principal Components Analysis with the Varimax Rotation Method to extract the constructs. The EFA Test results for all the constructs are accepted and proper as the data showed that 12 out of 63 factors have an Eigenvalue of more than (1). This supports the reliability of the data. On the contrary, when the Harman Single-Factor Test was performed to test for any common method bias, the results showed a data variance of more than 50% for the first factor of each independent variable (Fuller et al. 2016b). This shows that that the data exhibits a common method bias. This shows that the predictors exhibit some source of error during data collection. This could be due to not accounting for the common method bias which when developing the questionnaire. In

addition, the questionnaire also included questions on both independent and dependent variables with the same response scale (Kock, Berbekova & Assaf 2021), which could increase the chances of common method bias.

Next, a Linear regression analysis test was performed to verify the hypotheses. The test showed a $p\text{-value} < 0.001$ in table 6, which provides a significance the variables/factors against the Metaverse Use Intention. Table 7 shows the collinearity test results and the estimated coefficients and statistics for each predictor used in the ANOVA Model. In addition, it provides the Variance Inflation Factor (VIF) for each predictor. From the predictors used in the ANOVA Model, none has a VIF greater than 10, which supports the lack of an unapparent multicollinearity problems. This shows that no independent variables measure the same relationship as another independent variable. Table 7 also shows that each factor individually has no statistical significance on the MUI ($P\text{-value} > 0.05$). The data gathered showed no statistical significance correlation; however, it did provide the directional influence of the variables. Shown below is a summary of the effect of each variable on the adoption of metaverse in Aerospace Industry.

Table 10: Correlation Overview.

Independent Variable	Coefficient	Relation
PRA	0.041	Positive
PC	0.159	Positive
PNC	0.005	Positive
PT	0.013	Positive
PO	-0.012	Negative
PEI	-0.255	Negative

PTMS	0.283	Positive
POR	0.203	Positive
PON	-0.048	Negative
PEP	-0.005	Negative
PCP	0.076	Positive
PGS	0.236	Positive
PSCP	0.15	Positive

Relative Advantage, Compatibility, Non-Complexity, Trial-ability, Top Management Support, Organizational Readiness, Competitive Pressure, Governmental Support, and Supply Chain Pressure all have a positive b value as shown in table 10. This shows that these factors positively influence the intention to adopt metaverse. On the other hand, Observability, Environmental Impact, Organizational Needs, and Employee Pressure have a negative b value which shows the opposite, these factors have a negative influence on the adoption of the metaverse.

The highest positive contributions but with no statistical significance are:

- Perceived Top Management Support, $b=0.283$
- Perceived Governmental Support, $b=0.236$
- Perceived Organizational Readiness, $b=0.203$
- Perceived Compatibility, $b=0.159$
- Perceived Supply Chain Pressure, $b=0.150$

From the analysis performed, the data indicated the following:

- The Null Hypothesis is rejected.

- H1, H2, H3, H4, H7, H8, H11, H12, H13 are accepted as they have showed a positive correlation.
- H5, H6, H9, H10 are refuted as they have showed a negative correlation.

Perceived Top Management Support, Perceived Governmental Support, Perceived Organizational Readiness, Perceived Compatibility, and Perceived Supply chain Pressure all had the highest positive correlation to the Metaverse Use Intention. When the Perceived Observability, Perceived Environmental Impact, Perceived Organizational Needs, and Perceived Employee Pressure had the highest Negative correlation to the Metaverse Use Intention.

This research study intended to identify the influential factors on the adoption of metaverse in the Aerospace Industry. From the linear regression analysis, the TOE factors have no statistically significant effect on the adoption of metaverse. However, as the literature in table 2 proved, these factors have a correlation with the adoption of new technology. The Top Management Support is the first factor to influence the adoption of metaverse, which is supported by (Sargent, Hyland & Sawang n.d.; Kashada, Li & Koshadah 2018; Hsu et al. 2019b). As the higher management are the ones that create the atmosphere and culture of an organization. They have the ability to create a culture of growing, learning and development. Thus, the top management has a positive effect on the adoption of new technologies within an organization. They also have the ability to reallocate IT resources to support the adoption of metaverse. The Governmental Support is the second factor to influence the adoption of metaverse which is supported by (Ramanathan, Ramanathan & Ko 2014; Chatterjee et al. 52 2021). The Organizational Readiness is the third factor to influence the adoption of metaverse, which is supported by (Dube, Van Eck & Zuva 2020; Ali et al. 2021; Hradecky et al. 2022). The

fourth influential factor is Technological Compatibility. As it would be easier to adopt a technology that is more aligned with the current technology used by an organization. As this will provide less time consumption with regards to the understanding and trainings on the new technology (Kim 2000; Saaksjarvi 2003; Mndzebele 2013). Lastly, the Supply Chain Pressure has the 5th highest positive affect on metaverse adoption. As the Aerospace Industry closely works with different suppliers, which aligns with making this factor as significant. If the suppliers have an upgraded IT system, then it is preferred that the consumer would have the same IT system support (Patterson, Grimm & Corsi 2003; Kamariah Kamaruddin & Mohamed Udin 2009; Shamout et al. 2022). The Cronbach's, KMO, Bartlett Tests, and EFA showed that the data was reliable and valid. However, the Harman test showed that the data showed common method bias which was not controlled for when developing the questionnaire. In addition, the questionnaire also included questions on both independent and dependent variables with the same response scale (Kock, Berbekova & Assaf 2021). Additionally, 54% of the responses lack an understanding on what is metaverse in general and how does it benefit the aspects of the Aerospace Industry. It was clearly shown that the Aerospace Industry experts and professionals are unaware of the technological future, which creates a misguidance and a delay of implementation within the industry. professionals are unaware of the technological future, which creates a misguidance and a delay of implementation within the industry.

5.2 Research Conclusion

This research study is used to identify the main factors that influence the metaverse adoption in the Aerospace Industry. The study used the TOE framework, which assesses 3 factors that have an influence on metaverse adoption at an organizational level. The 3 main factors are: Technological Factors (Relative Advantage, Compatibility, Non-Complexity, Trial-ability,

Observability, Environmental Impact), Organizational Factors (Top Management Support, Organizational Readiness, Organizational Needs), and Environmental Factors (Competitive Pressure, Governmental Support, Supply Chain Pressure).

The study showed that the TOE framework factors had no major significance in influencing metaverse adoption. The findings suggest that the Aerospace Industry adoption of metaverse is positive driven by a few factors mainly top management support, governmental support, technological compatibility, Supply chain pressure and organizational readiness.

The theoretical background contributed the following to the research:

First: the study is the first paper to examine the factors that influence the possibility of implementing metaverse in the Aerospace Industry. These findings will contribute to the literature background of metaverse.

Second: the study is the first paper to use the TOE Framework to examine metaverse adoption in the Aerospace Industry. The framework is useful to examine a set of factors; technological, organizational, and environmental, in the organizational level decision making of adopting metaverse.

Thirds: the study shows that more research and data is required to determine where the focus lies. However, it proved that all 3 factors of TOE have a partial effect on the adoption of metaverse.

Top management should know their role in the adoption of metaverse. As they are the main key drivers to the acceptance of new technologies in an organization. This is done by following a top-down framework, starting from the top managers top reaching the lower-level employees. As the experience and knowledge are being shared through communications and training to their

employees. In addition, this study provided new means for metaverse developers to facilitate and accelerate the adoption of metaverse. It can provide a selling point with its advantages and benefits to the industry.

5.3 Limitations and Further Research

The research study is subject to some limitations that need to be recognized. The scope of the study was too general and included all organization types and considered all regions of the Aerospace Industry. The data was not evenly collected from each organization type or country. The Aerospace Industry worldwide are more or less aligned with their approvals and maintenance requirements but not in their technological development and future aspects. The questionnaire was shared for a short period of time, thus the data collected was not sufficient. The data collection method focused on convenience sampling which focused on the population that was accessible through networking, work environment and social platforms. The data showed no significance and incorporated method bias which shows that more data is required to be collected. Lastly, the research study is a steppingstone to the adoption and implementation of the Metaverse in the Aerospace Industry and other industries. Adoption of such technology still needs much research. The details on cybersecurity, legal aspects, and financial background behind the adoption of metaverse are still unclear. Nevertheless, some companies are already trying to implement some of the technologies that develop the Metaverse, i.e. Digital Twins.

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Appendices

Appendix I



Dear Participant,

We are currently undertaking a study titled "Adoption of Metaverse technology in the Aerospace Industry." The data collection part of the work requires a survey of the perception of experienced individuals in the Aerospace Industry.

Metaverse technology refers to a virtual world that enhances people interaction, engagement and learning via Extended Reality (XR), Virtual Reality (VR) and Augmented Reality (AR). The interaction can be used to interact with people from the same organization or from different organizations. Aerospace organizations are looking for its potential to improve their operations' efficiency and effectiveness. Adopting Metaverse technology can provide benefits such as the design/testing of parts, collaborating with key suppliers, enhancing sustainability and minimizing environmental impact.

This research investigates the main factors that influence the adoption of Metaverse technology in the Aerospace sector. Particularly, your input can help us identify the technological, organizational, and environmental factors that influence the adoption of the Metaverse in the aerospace industry.

We estimate that the questionnaire will take approximately 5–10 minutes of your time to complete.

Please be assured that all information will be held in the strictest confidence. Only aggregated and non-attributed data will be used in any subsequent publication.

Participation in this study is voluntary, and you may refuse to take part or exit the survey at any time without any consequences. If you withdraw, all your information will be discarded.

If you have any questions about the questionnaire or about participating in this research, please feel free to contact me by email at: 20194368@student.buid.ac.ae. For any further inquiries on the research, please contact my Director of Studies Dr. Maria Papadaki at: maria.papadaki@buid.ac.ae.

Thank you for your time and support.

Yours sincerely,

Leena Abou El Ella

Part I: Demographic Information										
1.	Are you familiar with Metaverse	☐ Not at all	☐ Somewhat Familiar		☐ Very Familiar					
2.	Organization Type	☐ Manufacturing (e.g., Rolls Royce)	☐ MRO	☐ Service Providers	☐ 1 st sub tier supplier spare parts	☐ 2 nd sub tier supplier spare parts	☐ Client	☐ End Client (Airlines e.g., Emirates)	☐ Regulatory Bodies	☐ Logistics Companies
3.	Where is your organization based?	Country list auto in question pro								
4.	Which of the following best describes your company's size?	☐ 1-49	☐ 50-249	☐ 250-999	☐ 1000-4,999	☐ 5,000-more				
5.	Age	☐ Younger than 18	☐ 18-24	☐ 25-34	☐ 35-44	☐ 45-54	☐ 55 and above			
6.	Education Level	☐ Less than high school	☐ High school diploma or equivalent (e.g., GED)	☐ Technical or vocational training	☐ Bachelor's degree (e.g., BA, BS)	☐ Master's degree (e.g., MA, MS)	☐ Doctorate degree (e.g., PhD, EdD) and above			
7.	How many years of experience do you have in the aerospace industry?	☐ 0-5 Years	☐ 6-10 Years	☐ 11-15 Years	☐ 16-19 Years	☐ 20+ Years				
8.	Departmental Level	☐ Design	☐ Supply Chain Management	☐ R&D	☐ IT	☐ Quality	☐ Executive	☐ Finance	☐ HR	☐ Marketing
9.	Which of the following best describes your job title?	☐ Administrative or Support Staff	☐ Professional or Technical Staff	☐ Manager or Supervisor	☐ Vice President or Director	☐ CEO, President, or Owner	☐ Other			



The following is a list of questions, which represent the factors that might influence the adoption of Metaverse. Please indicate [I.e., tick (✓)] the scale value that most closely reflects your level of agreement with the statements (Strongly Agree (1), Agree (2), Neither Agree nor Disagree (3), Disagree (4), Strongly Disagree (5))

Part II: Technological Characteristics						
This part attempts to identify the technological factors that influence the adoption of Metaverse technology in Aerospace Industry.						
#		Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
Part II.A: Perceived Relative Advantage: of the Metaverse in the aerospace sector will rely on how well the technology is used and incorporated into current procedures. Companies with a stronger competitive edge are more likely to have better adoption rates for their solutions and be able to clearly illustrate gains over more conventional approaches.						
PRA1	Metaverse reduces time. (For example, the Metaverse will speed up the meeting and work between colleagues and processing of decisions).	☐	☐	☐	☐	☐
PRA2	Metaverse reduces cost for traveling using VR/AR/XR technologies	☐	☐	☐	☐	☐
PRA3	Metaverse reduces cost for Virtual knowledge sharing and networking using VR/AR/XR technologies	☐	☐	☐	☐	☐
PRA4	Metaverse reduces cost for Virtual conferences and events using VR/AR/XR technologies	☐	☐	☐	☐	☐
PRA5	Metaverse reduces cost for training using VR/AR/XR technologies	☐	☐	☐	☐	☐
PRA6	Metaverse reduce cost for remote maintenance and troubleshooting	☐	☐	☐	☐	☐
PRA7	Metaverse reduces costs through collaborative design and prototyping. (For example, real-time collaboration of aerospace engineers and designers across the globe).	☐	☐	☐	☐	☐
PRA8	Metaverse reduces the use of physical materials using digital twin technology. (For example, creating virtual prototypes rather than physical ones)	☐	☐	☐	☐	☐
PRA9	Metaverse enhances data security through decentralized Blockchain platforms	☐	☐	☐	☐	☐
Part II.B: Perceived Compatibility: Degree to which a Metaverse enhances current technological aspect.						
PC1	Metaverse is compatible with the technological needs of my organization.	☐	☐	☐	☐	☐
PC2	Metaverse is consistent with the existing values and beliefs of my organization.	☐	☐	☐	☐	☐
Part II.C: Perceived Non-complexity: Degree to which a Metaverse is perceived as non-complex to understand or use.						
PNC1	Metaverse is easy to understand.	☐	☐	☐	☐	☐

PNC2	Metaverse is easy to use and manage.	☐	☐	☐	☐	☐
PNC3	Metaverse is easy to integrate with existing processes and current technologies in my organization.	☐	☐	☐	☐	☐
PNC4	Metaverse is scalable.	☐	☐	☐	☐	☐
Part II.D: Perceived Trial-ability - Degree to which a Metaverse can be experimented with as a trial before actual use in practice						
PTA1	Our organization has the chance to experiment with the Metaverse before completely adopting it.	☐	☐	☐	☐	☐
PTA2	Our organization places a high priority on trial-ability when deciding whether to employ cutting-edge technology like the Metaverse.	☐	☐	☐	☐	☐
PTA3	Our organization has access to the necessary resources and support to trial the Metaverse.	☐	☐	☐	☐	☐
Part II.E: Perceived Observability: Degree to which a Metaverse's benefits can be observed.						
PO1	It is easy to see and well-documented how the Metaverse (digital Twins) has benefited the aerospace sector.	☐	☐	☐	☐	☐
PO2	Our organization is aware of successful Metaverse (digital Twins) installations at other aerospace companies.	☐	☐	☐	☐	☐
PO3	The aerospace sector has a history of getting quantifiable benefits from the Metaverse.	☐	☐	☐	☐	☐
PO4	Our organization has access to trustworthy data on how the Metaverse affects the aerospace industry productivity, cost, and safety.	☐	☐	☐	☐	☐
Part II.F: Perceived Environmental Impact: refers to how much the aerospace industry believes the use of Metaverse technology will have either beneficial or negative effects on the environment.						
PEI1	My organization can reduce its environmental impact by embracing the Metaverse.	☐	☐	☐	☐	☐
PEI2	My organization can reduce waste and improve sustainability by using the Metaverse.	☐	☐	☐	☐	☐
PEI3	The Metaverse's adoption by my origination is in line with international initiatives to fight climate change and advance environmental sustainability.	☐	☐	☐	☐	☐
PEI4	My organization acknowledges the Metaverse as a tool for lessening the	☐	☐	☐	☐	☐

	need for actual travel and, thus, reducing greenhouse gas emissions.					
PEI5	My organization can use the Metaverse to bring more eco-friendly methods to the aerospace sector.	☐	☐	☐	☐	☐
PEI6	Adopting Metaverse will increase technological waste (e-waste) in the form of electronic parts or equipment.	☐	☐	☐	☐	☐
PEI7	Adopting Metaverse will increase environmental waste (e.g. CO2)	☐	☐	☐	☐	☐
PEI8	My organization's efforts to be more environmentally friendly could benefit from Metaverse.	☐	☐	☐	☐	☐

Part III: Organization Characteristics						
This part attempts to identify the organizational factors that influence the adoption of Metaverse in the aerospace industry.						
#		Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
Part III.A: Perceived Top Management Support: The degree to which employees in an organization believe that their top management is dedicated to and supportive of the implementation of Metaverse technology						
PTMS1	Top management in my organization is aware of the benefits that Metaverse can provide.	☐	☐	☐	☐	☐
PTMS2	Our organization has well defined objectives and plans for implementing the Metaverse in the aerospace sector.	☐	☐	☐	☐	☐
PTMS3	The management of our organization is flexible and encourages the investigation of novel technologies, such the Metaverse.	☐	☐	☐	☐	☐
PTMS4	Top management in my organization fully supports the adoption of Metaverse.	☐	☐	☐	☐	☐
PTMS5	Our organization is prepared to make any relevant future investments in metaverse to support it as a top priority.	☐	☐	☐	☐	☐
Part III.B: Perceived Organizational Readiness: The degree to which an organization is prepared and equipped to implement Metaverse technology						
POR1	To help the adoption of cutting-edge technologies like the Metaverse, our organization is dedicated to lifelong learning and skill development.	☐	☐	☐	☐	☐
POR2	The decision-makers in my organization are aware of the potential opportunities and risks of the Metaverse.	☐	☐	☐	☐	☐

POR3	My organization will need additional staff with Metaverse skills to run and develop Metaverse applications	☐	☐	☐	☐	☐
POR4	My organization will need external support in legal complexities regarding the metaverse	☐	☐	☐	☐	☐
POR5	My organization will need external support in business management in regards to the Metaverse	☐	☐	☐	☐	☐
POR6	My organization will need external support in technical capability with regards to the Metaverse.	☐	☐	☐	☐	☐
Part III.C: Perceived Organizational Needs						
PON1	Our organization has a very clear need for the Metaverse to boost its efficiency and effectiveness.	☐	☐	☐	☐	☐
PON2	Our organization is aware of the necessity to embrace the Metaverse (Digital Twins) in order to stay up to date with the aerospace industry's innovations in technology.	☐	☐	☐	☐	☐
Part III.D: Perceived Employee Pressure: The degree to which employees believe that their thoughts and input are respected and taken into account in decision-making processes connected to the deployment of Metaverse technology						
PEF1	Our organization's employees have shown interest in exploiting (Exploring) the Metaverse for numerous aviation applications.	☐	☐	☐	☐	☐
PEF2	The introduction of the Metaverse in our company has been decided (will be decided) after considering employee feedback.	☐	☐	☐	☐	☐
PEF3	The majority of the employees at our organization believe that exploring the Metaverse can boost productivity and efficiency.	☐	☐	☐	☐	☐
PEF4	The Metaverse, in the opinion of our employees, has the potential to improve teamwork and communication.	☐	☐	☐	☐	☐
PEF5	Our organization values feedback from staff and considers it while developing and implementing the Metaverse.	☐	☐	☐	☐	☐