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Identifying Barriers To Airport Digitalization – Using Analytical Hierarchy Process

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ABSTRACT

Airport digitalization has become pivotal for improving airport economics and stakeholder engagement, yet its implementation faces significant barriers. This study identifies and ranks these barriers using the Analytical Hierarchy Process (AHP) technique, providing actionable insights for policymakers and airport managers. Expert analysis reveals cybersecurity concerns and passenger inconvenience as the two most critical challenges. Cybersecurity remains a pressing issue due to the growing reliance on interconnected digital systems vulnerable to cyber threats, demanding robust protections and continuous vigilance. Passenger inconvenience emerges as a key barrier, as the success of digital initiatives depends on user adoption and seamless experiences, often hindered by resistance to change, inadequate infrastructure, and lack of awareness. By highlighting these factors, the study offers a strategic framework for addressing these challenges, enabling stakeholders to advance digital transformation, improve operational efficiency, and enhance passenger satisfaction.

Keywords: Airport efficiency, digitalization, Analytical Hierarchy Process (AHP)

INTRODUCTION

Airports are continually introducing new digital initiatives to enhance their capabilities. While maintaining safety and security remains their top priority, the competitive nature of the aviation industry compels airport management to prioritize improving the efficiency of airport operations and business processes. Airports face significant challenges in digitization, such as developing advanced IT infrastructure. This paper explores digitization trends, the framework for implementing TAM, and the managerial shifts, driven by innovations. It also examines the technological challenges at Romania's Henri Coandă Airport, proposing solutions for areas such as passenger facilitation, security, customs, border control, and passenger support (Zaharia, S. E., & Pietreanu, C. V. 2018).

In recent years, the digital revolution has been progressively implemented across various segments and functions at airports. These transformations involve the automation of processes, and the digitization of information accessibility. These innovations are vital, as safety remains a fundamental priority in international air transportation (Thums et al., 2023).

The study explores digital transformation at European airports using the Technology Adoption Framework for Airports (TAFA). Based on interviews and public sources, it finds these airports focused on improving passenger experience and efficiency, by adoption Industry 4.0 expertise. However, the lack of coordination among organizations like ACI, ICAO, and IATA results in fragmented solutions and inconsistent user experiences. The study predicts airports will remain technological islands, with limited integration between airports, airlines, and transport providers, hindering a seamless travel experience (Dini, L., Schulke, A., & Klingenberg, C. 2023).

Investments in digital technologies for airports were projected to increase by 40% in 2020, aiming to enhance operational efficiency, expand capacity, and deliver an improved customer experience (Little, 2015).

Digitalization and its impact on airports

Digitization efforts at airports and airlines aim to enhance efficiency and customer experience, with a strong focus on flight and aviation security. Airports known for sustainability, such as Schiphol, and Heathrow are leading the way in digital advancements to improve operational efficiency, security, and passenger experience. The adoption of cloud computing primarily targets real-time examining of procedures and enhancing human-hardware interfaces, making these technologies ideal for airports looking to further automate their operations (Gürsel, et al, 2023).

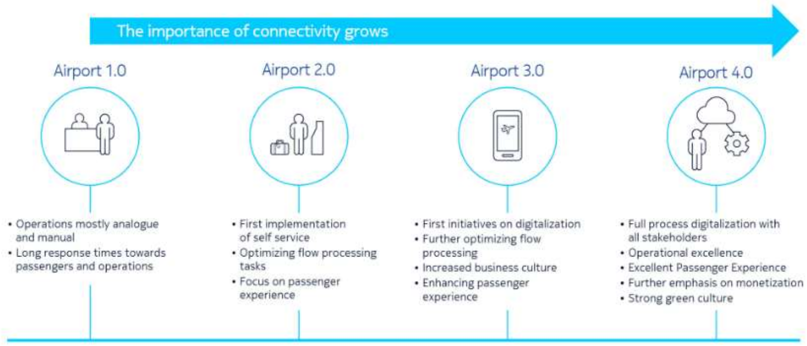

Figure 1.1 – Advent of Airports

Smart airports no longer react to passenger needs; they proactively harness Big Data, open data, and the Internet of Things (IoT) to develop innovative, integrated systems that enhance efficiency and passenger experience. Unlike traditional airports, which primarily address immediate demands, smart airports leverage cutting-edge technologies to create advanced solutions. These include energy management systems that dynamically control lighting and air conditioning based on real-time occupancy, as well as self-boarding and biometric services. These technologies streamline operations and contribute, to sustainability efforts, reduce costs, and provide a more personalized and efficient travel experience (Jayasuriya, N. A., & Rajapaksha, A. 2020).

This paper explores the growing importance of digitalization in the air transport sector, particularly at airports, and the need for a transition to Industry 4.0 to improve global performance. It addresses key questions related to assessing current maturity levels, defining progress strategies, and identifying the necessary skills for success. The paper presents a unique approach to evaluating airport maturity and determining the skills required for a successful transition to Airport 4.0 (Marmier et al, 2023).

The Airport Ecosystem

According to the International Air Transport Association (IATA), COVID-19 accelerated collaboration and opened avenues for data monetization. Aviation CIOs acknowledge the critical need for strategic investments in technology to address the challenges posed by legacy applications, which are costly to maintain. The aviation industry's priorities have been restructured to focus on energy transition, adopting innovation, and expanding sovereign technologies.

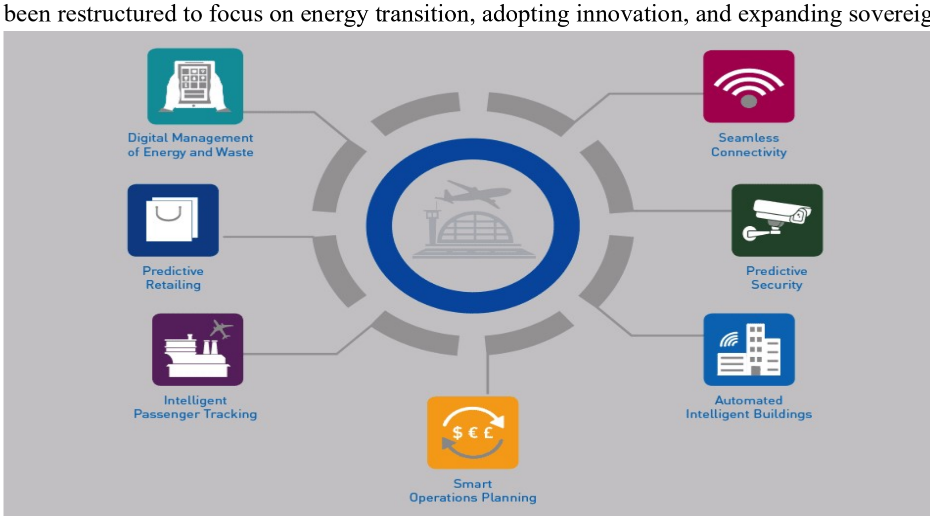

Figure 1.2 – Airport Ecosystem

The airport ecosystem requires stakeholder engagement to foster communication flow and, enable efficient operation. Technological innovations are driving factors for improved performance and revenue generation. Barriers adversely impacting the airport ecosystem must be identified, and addressed to achieve holistic development.

Barriers to Airport Digitalization

As an infrastructure heavily reliant on technology, online connectivity, and the use of open and big data, airports are increasingly vulnerable to cyber-attacks and information breaches (Tan & Masood, 2021). These cyber-threats can disrupt airport operations, steal sensitive information, and put passengers at risk. Cyber-attacks may take various forms, including malware, DDoS attacks, and ransomware. (Lykou et al. 2018) identify insider threats as a significant cybersecurity risk at airports, arising from employees, contractors, or external providers with access to sensitive information. These risks can stem from negligence, malicious intent, or unintentional actions. To reduce such threats, effective access control, staff training, and oversight are needed. However, the integration of various smart systems complicates security, as each may follow different protocols. Standardized security procedures, regular audits, and data sharing across the industry are essential to address these challenges. While advanced communication technologies improve airport operations, they also increase cybersecurity risks.

Emerging technologies offer significant benefits and enhance operational efficiency. However, a key challenge they present is the high cost of their development and ongoing maintenance when implemented at airports (Tan & Masood, 2021).

LITERATURE REVIEW

Table 1.1 Identified Barriers

S.No	Name of Barrier	Description	Reference
S1	Cyber Security	The integration of new digital technologies and systems can increase the attack surface for cybercriminals, leaving airports susceptible to various virtual threats, such as hacking, data breaches, and ransomware attacks.	Rajapaksha & Jayasuriya (2020). Gopalakrishnan et al., 2013). Urban (2017). Ukwandu, Ben-Farah, Hindy & Bures (2022). (Lykou et al., 2019).
S2	Internal Organisation Issues	The internal organizational issue that can hinder airport digitalization is a lack of coordination and collaboration among departments. Siloed departments and lack of communication can result in inefficient processes and a fragmented approach to digitalization initiatives	Gupta, S. (2018). Lideroth et al., (2018). Kovrigin & Vasiliev (2020), Suau-Sanchez (2021)
S3	Passenger Inconvenience	While digitalization has the potential to improve the passenger experience, poorly designed digital systems and processes can increase passenger inconvenience.	Siikonen & Kaakinen, Patel (2018), Dragos, Andrei & Mirela-Maria (2016)
S4	Resistance to Change	In the aviation industry, resistance to change can manifest itself in several ways, such as employees' reluctance to adopt new digital technologies, lack of buy-in from management, or opposition from unions.	Wanu et al., (2023)
S5	Data Availability, Quality and Management	Airports generate huge amounts of data, including passenger information, flight schedules, and cargo information. Poor data quality can lead to errors in	Chen et al, (2021). Shafiq, A., & Matin, H. (2020)

		decision-making and can result in inefficient operations.	
S6	Cost Involved	The implementation of digital technologies and systems requires a significant investment of resources, including the cost of acquiring and installing new hardware and software, as well as the cost of training staff to use these systems.	Joel et al, (2023). Pereira et al., (2013). Motaung et al, (2021).
S7	Interference of Regulatory Authorities	The aviation industry is heavily regulated, and regulatory authorities are responsible for ensuring compliance with safety and security standards.	Reza, Mohiuddin, (2023). Raj et al, (2020). Jaiswal et al, (2024).
S8	Erratic IT	The reliability of IT infrastructure is crucial for airports, as any downtime or system failures can cause significant disruptions to airport operations and passenger experience.	Kovrigin & Vasiliev (2020), Koseoglu and Keskin (2019).

The study is focused on identifying the barriers that impact airport digitization and subsequently ranks them to facilitate adequate resource allocation.

Research Process:

The Analytic Hierarchy Process (AHP), introduced by Saaty in 1980, is a mathematical method for Multi-Criteria Decision-Making (MCDM) that breaks complex problems into a hierarchical structure. It has been widely applied in various fields, including Bevilacqua and Braglia's (2000) work on optimizing maintenance strategies for an oil refinery, Singh et al.'s (2007a, b) development of a Composite Sustainability Performance Index for the steel industry, and Isiklar and Buyukozkan's (2007) evaluation of mobile alternatives based on user preferences. Lam and Chin (2005) used AHP in collaborative new product development to rank critical success factors in conflict management, while Salmeron and Herrero (2005) applied it to prioritize success factors in executive information systems. These examples highlight AHP's versatility in providing structured, data-driven insights across diverse sectors.

The steps involved in the AHP process are as follows:

Step 1: Clearly define and outline the objectives of the complex problem.

Step 2: Break down the problem into a hierarchical structure using group decision-making or survey techniques. This structure is divided into multiple levels: the top level represents the overall goal, which is then broken down into criteria at the next level. These criteria are further subdivided into sub-criteria to provide more detailed information. This process continues until no further decomposition is possible.

Step 3: To assess the relative importance of each criterion, pairwise comparisons are conducted using a decision matrix. The decision-making matrix is built with input from decision-makers and experts, based on Saaty's (1994) nine-point scale. Elements under a common node in the hierarchy are compared with each other. For "n" elements under a node, n(n-1)/2 comparisons are made.

Step 4: Once the decision-making matrix is established, the next step is to determine the priority weights of the elements using the maximum eigenvalues and eigenvectors.

Step 5: In this step, the consistency of the pairwise comparisons is assessed. Inconsistency is measured using the consistency index (CI), while coherence is evaluated through the consistency ratio (CR), which is then calculated.

Step 6: After determining the priority weights (local weights) for each element, the next step is to calculate the global weights of all elements in relation to the goal defined in the AHP model.

Step 7: Lastly, once the global weights are calculated, the elements are ranked in descending order based on their global prioritization.

Discussion and Analysis

Step 1:

It involves comparing the given factors to create a consolidated numeric table. Each factor—Cyber Security, Internal Organizational Issues, Passenger Inconvenience, Resistance to Change, Data Availability, Cost Involved, Regulatory

Authority, and Outdated and Unreliable IT—has been evaluated against others regarding their relative importance or influence. The values in the table reflect these comparisons, where higher numbers indicate greater significance of one factor over another. This step lays the groundwork for further normalization and analysis to determine each factor's relative weights systematically. Each factor's comparisons across the matrix remain intact, preparing the normalized matrix for subsequent computations and evaluations.

Table 1.2. Shows the paired comparison of the factors

Factors	Cyber Security	Internal Organizational Issues	Passenger Inconvenience	Resistance to Change	Data Availability	Cost Involved	Regulatory Authority	Outdated and Unreliable IT
Cyber Security	1.0000	8.1000	5.9125	6.2000	7.5000	7.1000	5.9000	7.0111
Internal Organizational Issues	0.1248	1.0000	2.6736	3.0839	0.2069	0.1685	2.5681	0.1240
Passenger Inconvenience	0.9444	4.0635	1.0000	5.7454	5.0851	6.7333	6.4254	7.6111
Resistance to Change	0.1654	4.3546	2.1879	1.0000	1.0958	0.2166	1.9855	0.1476
Data Availability	0.1542	7.8000	2.2722	6.9111	1.0000	6.5000	8.3000	7.5143
Cost Involved	0.1679	7.5000	0.4986	7.3000	0.1517	1.0000	7.3000	6.9111
Regulatory Authority	0.2548	5.3668	1.7014	5.9222	0.1226	0.1519	1.0000	0.2375
Outdated and Unrealiable IT	1.0931	8.1000	1.0077	7.5000	0.8153	1.0466	6.6000	1.0000

<u>Step 2</u>:

In this step, the sum of the values in each column of the normalized matrix is calculated. These column sums represent the total weight of each factor when compared across all other factors. The computed sums are listed at the bottom of the table, providing the basis for normalization in the next step.

<u>Table 1.3. shows sum of normalized matrix of the factors</u>

Factors	Cyber Security	Internal Organizational Issues	Passenger Inconvenience	Resistance to Change	Data Availability	Cost Involved	Regulatory Authority	Outdated and Unrealiable IT
Cyber Security	1.0000	8.1000	5.9125	6.2000	7.5000	7.1000	5.9000	7.0111
Internal Organizational Issues	0.1248	1.0000	2.6736	3.0839	0.2069	0.1685	2.5681	0.1240
Passenger Inconvenience	0.9444	4.0635	1.0000	5.7454	5.0851	6.7333	6.4254	7.6111
Resistance to Change	0.1654	4.3546	2.1879	1.0000	1.0958	0.2166	1.9855	0.1476
Data Availability	0.1542	7.8000	2.2722	6.9111	1.0000	6.5000	8.3000	7.5143
Cost Involved	0.1679	7.5000	0.4986	7.3000	0.1517	1.0000	7.3000	6.9111

Regulatory Authority	0.2548	5.3668	1.7014	5.9222	0.1226	0.1519	1.0000	0.2375
Outdated and Unrealiable IT	1.0931	8.1000	1.0077	7.5000	0.8153	1.0466	6.6000	1.0000
Sum	2.8114	38.1848	16.2462	36.1627	15.1623	21.8704	33.4790	29.5567

Step 3:
Each value in the normalized matrix is divided by the respective column sum calculated in Step 2. This process generates the pairwise comparison matrix, where each entry represents the relative weight of a factor in relation to others. This matrix is essential for deriving the priority vector, as it standardizes all comparisons on a consistent scale for further analysis.

Table 1.4. Shows the matrix with comparative relative factor weight

Factors	**Cyber Security**	**Internal Organizational Issues**	**Passenger Inconvenience**	**Resistance to Change**	**Data Availability**	**Cost Involved**	**Regulatory Authority**	**Outdated and Unrealiable IT**
Cyber Security	0.356	0.212	0.364	0.171	0.495	0.325	0.176	0.237
Internal Organizational Issues	0.044	0.026	0.165	0.085	0.014	0.008	0.077	0.004
Passenger Inconvenience	0.336	0.106	0.062	0.159	0.335	0.308	0.192	0.258
Resistance to Change	0.059	0.114	0.135	0.028	0.072	0.010	0.059	0.005
Data Availability	0.055	0.204	0.140	0.191	0.066	0.297	0.248	0.254
Cost Involved	0.060	0.196	0.031	0.202	0.010	0.046	0.218	0.234
Regulatory Authority	0.091	0.141	0.105	0.164	0.008	0.007	0.030	0.008
Outdated and Unrealiable IT	0.389	0.212	0.062	0.207	0.054	0.048	0.197	0.034

Step 4: To determine the criteria weights, the rows of the pairwise comparison matrix are summed, and the total is divided by the number of dimensions (in this case, the number of criteria). This normalization process ensures that the derived weights reflect the relative importance of each criterion in the decision-making process. The resulting criteria weights are shown in the final column of the table, representing the normalized values for each criterion.

Table 1.5. Shows the criteria weights of the matrix

Factors	**Cyber Security**	**Internal Organizational Issues**	**Passenger Inconvenience**	**Resistance to Change**	**Data Availability**	**Cost Involved**	**Regulatory Authority**	**Outdated and Unrealiable IT**	**Weights**
Cyber Security	0.356	0.212	0.364	0.171	0.495	0.325	0.176	0.237	0.292
Internal Organizational Issues	0.044	0.026	0.165	0.085	0.014	0.008	0.077	0.004	0.053
Passenger Inconvenience	0.336	0.106	0.062	0.159	0.335	0.308	0.192	0.258	0.219

Resistance to Change	0.059	0.114	0.135	0.028	0.072	0.010	0.059	0.005	0.060
Data Availability	0.055	0.204	0.140	0.191	0.066	0.297	0.248	0.254	0.182
Cost Involved	0.060	0.196	0.031	0.202	0.010	0.046	0.218	0.234	0.125
Regulatory Authority	0.091	0.141	0.105	0.164	0.008	0.007	0.030	0.008	0.069
Outdated and Unrealiable IT	0.389	0.212	0.062	0.207	0.054	0.048	0.197	0.034	0.150

Step 5: Assign weights to each factor, reflecting their relative importance. A higher weight indicates a more significant factor in the decision-making process. To determine these weights, consider the potential impact of each factor on the overall goal.

Table 1.6. Shows the weights of the factors

Factors	Weights
Cyber Security	0.292
Internal Organizational Issues	0.053
Passenger Inconvenience	0.219
Resistance to Change	0.060
Data Availability	0.182
Cost Involved	0.125
Regulatory Authority	0.069
Outdated and Unreliable IT	0.150

Table 1.7. Shows the ranking of the factors in terms of weight and importance

Factors	Weights	Rank
Cyber Security	0.292	1
Passenger Inconvenience	0.219	2
Data Availability	0.182	3
Outdated and unreliable IT	0.150	4
Cost Involved	0.125	5
Regulatory Authority	0.069	6
Resistance to Change	0.060	7
Internal Organizational Issues	0.053	8

Limitations

The AHP software utilized for data visualization presents results as percentages, ensuring clarity in interpretation. However, inconsistency in the level of digitalization across airports poses a significant challenge; while some airports have fully embraced advanced digital technologies, others remain in early stages, complicating the comparability of research findings. Addressing barriers to digitalization demands extensive technical expertise in areas such as data analytics, cybersecurity, and digital infrastructure, often necessitating collaboration with domain specialists to ensure robust and reliable outcomes. Access to critical data further exacerbates the complexity, as datasets from airports, airlines, and other stakeholders are frequently restricted due to privacy regulations and confidentiality concerns. Furthermore, the limited number of airports with fully implemented digital technologies results in a constrained sample size, potentially limiting the generalizability and broader applicability of the research findings.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

REFERENCES

1.Air Transport IT review: A new era of intelligence, 2017, https://www.sita.aero.

2.Bevilacqua, M. and Braglia, M. (2000), "The analytic hierarchy process applied to maintenance strategy selection", Reliability Engineering & System Safety, Vol. 70, pp. 71-83.

3.Dini, L., Schulke, A., & Klingenberg, C. (2023). Digital transformation: An analysis of the current state within Europe's top five digital airports. Journal of Airport Management, 17(4), 429-442.

4.European Commission, Green Paper: Promoting a European Framework for Corporate Social Responsibility, 2001, p.21.

5.Gardy, A., Canada, R., Digital trends & opportunities for Airports, ACI-NA World Annual Conference, Sept. 2016.

6.Guiu, A. G., Feasibility study of introducing smart technologies in Barcelona airport, Final project degree, Report, Universitat Politecnica de Catalunya BarcelonaTech, 2016, pp. 75-77.

7.Gupta, S. (2018). Organizational barriers to digital transformation.

8.Halpern, N., Mwesiumo, D., Suau-Sanchez, P., Budd, T., & Bråthen, S. (2021). Ready for digital transformation? The effect of organisational readiness, innovation, airport size and ownership on digital change at airports. Journal of Air Transport Management, 90, 101949.

9.Hoffman, J., The 2018 digital transformation report, Skift Report 2017, https://wwwimages2.adobe.com/ International Air Transport Association, Future of the airline industry 2035, 2017. International Airport Review, Tech failure at Gatwick Airport caused chaos during busy summer rush, August 2018,

10. Isiklar, G. and Buyukozkan, G. (2007), "Using a multi-criteria decision making approach to evaluate mobile phone alternatives", Computer Standards & Interfaces, Vol. 29, pp. 265-74.

11. Lam, P. and Chin, K. (2005), "Identifying and prioritizing critical success factors for conflict management in collaborative new product development", Industrial Marketing Management, Vol. 34, pp. 761-72

12. Little, A. D. (2015). Airports 4.0: Impact of digital transformation on airport economics. Travel and transportation, 3-19.

13. Linderoth, H. C., Elbanna, A. R., & Jacobsson, M. (2018). Barriers for Digital Transformation: The Role of Industry. In ACIS (p. 84).

14. Lykou, G., Anagnostopoulou, A., & Gritzalis, D. (2018). Smart Airport Cybersecurity: Threat Mitigation and Cyber Resilience Controls. Sensors, 4(7). https://doi.org/10.3390/s19010019.

15. Gopalakrishnan, K., Govindarasu, M., Jacobson, D. W., & Phares, B. M. (2013). Cyber security for airports. International Journal for Traffic and Transport Engineering, 3(4), 365-376.

16. Gürsel, S., Demir, R., & Rodoplu, H. (2023). The effect of digitalisation on sustainability and smart airport. International Journal of Sustainable Aviation, 9(1), 26-40.

17. Jayasuriya, N. A., & Rajapaksha, A. (2020). Smart Airport: A Review on Future of the Airport Operation.

18. Marmier, F., Filipas, I., & Zaharia, S. E. (2023). Transition 4.0 for the Airport Industry. IFAC-PapersOnLine, 56(2), 3698-3703.

19. Pereira, M. R., Simões, F., Carlos Sá, J., Ferreira, I., & Martinho, P. (2021). International Conference on Quality, Innovation and Sustainability–ICQIS2020-Book of Abstracts. In International Conference on Quality, Innovation and Sustainability–ICQIS2020-Book of Abstracts. Instituto Politécnico de Leiria.

20. Salmeron, J.S. and Herrero, I. (2005), "An AHP-based methodology to rank critical success factors of executive information systems", Computer Standards & Interfaces, Vol. 28, pp. 1-12.

21. Thums, J., Künzel, L., Klumpp, M., Bardmann, M. M., & Ruiner, C. (2023). Future air transportation and digital work at airports–Review and developments. Transportation Research Interdisciplinary Perspectives, 19, 100808.

22. Emily K. Okero. (2024). Qualitative Study on Cyber Security Attacks Affecting the Civil Aviation Industry. Department of Doctoral Studies, Colorado Technical University (2024).

23. Singh, R.K., Garg, S.K., Deshmukh, S.G. and Kumar, M. (2007a), "Modelling of critical success factors for implementation of AMTs", Journal of Modelling in Management, Vol. 2 No. 3, pp. 232-50.

24. Tan, J. H., & Masood, T. (2021). Adoption of Industry 4.0 technologies in airports-A systematic literature review. 1-25.

25. Ukwandu, E., Ben-Farah, M. A., Hindy, H., Bures, M., Atkinson, R., Tachtatzis, C., ... & Bellekens, X. (2022). Cyber-security challenges in aviation industry: A review of current and future trends. Information, 13(3), 146.

26. Urban, J. A. (2017). Not Your Granddaddy's Aviation Industry: The Need to Implement Cybersecurity Standards and Best Practices within the International Aviation Industry. Alb. LJ Sci. & Tech., 27, 62.

27. Zaharia, S. E., & Pietreanu, C. V. (2018). Challenges in airport digital transformation. Transportation research procedia, 35, 90-99.