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عنوان البحث

الذكاء الاصطناعي في إدارة المخاطر التشغيلية: دراسة حالة مطار الطائف الدولي.

إعداد الطالب/ طارق الصاعدي

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**Artificial Intelligence in Operational Risk Management: A Case Study of Taif
International Airport.**

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List of Abbreviations

- AI – Artificial Intelligence
- ORM – Operational Risk Management
- ML – Machine Learning
- NLP – Natural Language Processing
- ICAO – International Civil Aviation Organization
- KSA – Kingdom of Saudi Arabia

Introduction

Background of the Study

Artificial Intelligence (AI) is revolutionizing the aviation industry, and nowhere would it be noticed more than in the realm of risk management, where it can analyze enormous large sets of data, predict probable perils, and boost decision-making (Youseftorkaman et al., 2023). Airlines, airports, and aerospace companies leverage AI technologies such as

machine learning, computer vision, and big data analytics to improve safety, efficiency, and customer satisfaction. Through the integration of AI systems, real-time performance monitoring, anomaly detection, and recommendation of corrective actions can be performed, significantly minimizing the risks caused by human error and optimizing operations. AI also helps pilots and air traffic controllers by comprehensively consolidating weather reports and traffic patterns, thus intending enhancements in situational awareness and timely interventions. AI-powered predictive maintenance systems analyze aircraft data and forecast repair needs in real time to minimize unexpected breakdowns and carry out timely interventions.

The push for AI-driven risk management in aviation globally is high, and regulatory bodies and industry stakeholders are taking significant steps to safely and efficiently integrate AI into aviation. In the European Union, the European Union Aviation Safety Agency (EASA) has drawn up a comprehensive framework in its "Artificial Intelligence Roadmap 2.0." It is working on Machine Learning Application Approval (MLEAP) to approve AI systems used in safety-related domains (Emanuilov & Dheu, 2021). The FAA's Roadmap for Artificial Intelligence Safety Assurance recommends strict safety assurance processes before deploying AI systems and phased integration of AI, starting with lower-risk applications such as predictive maintenance. Such global initiatives emphasize the role of collaboration, ongoing monitoring, and ethical issues in AI risk management in aviation. The global artificial intelligence in aviation market size is projected to reach USD 1493.02 million in 2025 from USD 1015.87 million in 2024 (Straits Research, 2024).

Overview of Taif International Airport

The Taif International Airport was established in 1976, some 27 km northeast of Taif city in Saudi Arabia Kingdom Makkah Province. Starting as a domestic airport, it became a regional airport in 2009 to service international airlines as the city's population grew and

relieved congestion at its main airports. Two hours from Mecca, the airport is in a strategic location about 70 kilometers away from the Saudi holy city. The construction of a new Taif International Airport, 21 kilometers southeast of the existing facility and with a projected capacity of 2.5 million passengers by 2030, aligns with Saudi Arabia's Vision 2030 (Abonomi et al., 2022). This development indicates how the region strives to upgrade its aviation infrastructure to cater to rising passenger demand.

Like any other airport in the world, Taif International Airport also experiences some of operational risks which may be somewhat managed by the application of AI solutions and their construction. These risks imply that effective and efficient risk management measures have to be put in place and implemented, in relation to the various aspects of ground navigation and security risks. Implementing AI into the risk management system of Taif International Airport will help in providing better measures, monitoring, and decision-making. Technological advancements such as artificial intelligence can be used to monitor risks on a daily basis, respond to potential issues, and produce detailed reports that help to better understand operational risks. With the gradual advancement of Taif International Airport toward the development process, the application of AI in the management of risks in the operation can be considered as vital in the achievement of safety, efficiency, and reliability of operations.

Research Problem

Like most other airports in the expanding aviation industry, Taif International Airport has several operational risk management issues.

Along with these, there is a requirement that the safety and security standards be very stringent, resources have to be appropriately managed, and operations have to be coordinated correctly. According to the 2021 AIB Annual Safety Report, one particular challenge occurred 68 times (at King Khalid International Airport), namely ‘Ground Navigation Errors.’ None of these events directly affected safety, but they added workload to flight crews, tower controllers, and airport personnel, which might ultimately hurt safety. Technological breakthroughs, cybersecurity threats, and climate change add to these challenges, causing significant operational disruption risks. In addition, just like many aviation construction projects in Saudi Arabia, Taif International Airport could also be at risk due to poor risk management planning, budget overrun, and project delays on schedule.

However, the challenge of these tendencies requires more effective solutions, which AI-based solutions can provide. As a result of AI, vast amounts of data can be analyzed in real-time, potential risks can be predicted, and processes can be automated, increasing safety and efficiency. An example is how artificial intelligence-integrated surveillance technologies are more effective in identifying and preventing security threats than traditional surveillance technologies. Maintenance planning and management can, therefore, be done with the aircraft data to identify the likelihood of repair and avoidability of breakdowns while ensuring the aircraft are available on time. It is also helpful for the workaround of ground navigation errors in providing real-time information and alerting the flight crew and air traffic controllers. Applying AI to the risk management process of Taif International Airport will help the company to identify and mitigate them more effectively, enhance operational safety, and optimize the efficiency of its operations in the new conditions of a relevant environment.

Additionally, the Kingdom’s focus on airport development and privatization makes the need to introduce AI-based solutions at Taif International Airport even greater. The new

Taif International Airport is expected to cater to the projected increase in demand up to 2055 and accommodate 2.5 million passengers per year by 2030. However, the development and investors in a build transfer operation (BTO) contract may experience difficulties so that risk management will be crucial. If integrated into its operational risk management framework, Taif International Airport can leverage AI to proactively detect and avoid risks, enhance overall safety, and operate efficiently in a growing, complex, dynamic environment.

Significance of the Study

The significance of the study is to enhance the aviation safety and effectiveness of the Taif International Airport and other related airports. This paper focuses on using AI in operational risk management to inform airport operators of the risks and recommend ways of dealing with them and improving efficiency. For instance, through AI, it is possible to have maintenance prediction systems that examine aircraft data and identify areas that require tuning before a breakdown occurs. Further, AI can find the ideal routes to be taken that will help reduce overcrowding and help pilots and air traffic controllers communicate more effectively to enhance safety and efficiency. It assists in furthering a culture of a more proactive risk management approach, which is crucial for ensuring safety and productivity in airports, especially in the current and evolving nature of the aviation industry.

Furthermore, this paper extends the current literature on risk management in AI implementation as it provides insight into the implementation of AI in a given airport environment. It is also well understood that AI has the potential to be applied in the field of aviation. However, few studies investigate how this technology is used and how it impacts the environment. This study addresses this gap through a detailed analysis of the challenges and opportunities of adopting AI at Taif International Airport. Additionally, the research

guides the development of best practices for AI-driven risk management in the aviation industry, which can serve as a guide for other airports looking to leverage AI to enhance safety and efficiency. According to reports, the AI market in aviation is anticipated to grow from USD 1493.02 million in 2025. Hence, this research is critically important for providing direction to developing and utilizing AI solutions in the aviation domain.

Objectives of the Study

The first primary research goal is to determine which specific AI applications can help airport risk management improve safety, security, and operational efficiency. Other applications touch upon AI-powered surveillance systems that apply facial recognition algorithms to identify people on watchlists and immediately inform security personnel. In addition, AI can be used to predict safety risks from incident reports and operational data. In addition, airport risk management uses AI applications such as machine learning algorithms trained on enormous amounts of data from past security incidents to identify patterns of prohibited items or suspicious behavior. The objective also includes understanding the role of AI in enhancing passenger flow and minimizing congestion, as well as the overall passenger experience using innovative queue management and personalized services.

The second key research objective is to evaluate the effectiveness of AI in avoiding risks in airport operations. This requires assessing how AI systems improve situational awareness by combining disparate data sources (such as weather reports and traffic patterns) into one view for pilots and air traffic controllers so that the pilots and controllers can make informed decisions rapidly. Additionally, evaluating how AI helps find vulnerabilities, determine new threats, and create a complete Safety Risk portfolio to determine and meet

the most important safety risks. Also, effectiveness will be measured in terms of the capacity of AI to forecast equipment failures for timely interventions through predictive analytics to increase overall reliability and reduce downtime.

Finally, the research highlights the challenges of AI adoption in airport risk management. This poses the challenge of ensuring the trustworthiness of AI systems, which is achieved through transparency, regular testing, and validation of the systems and software. Another threat is dealing with ethical issues and algorithmic bias to guarantee fair and equitable assumptions. This objective also involves assessing how airport staff are ready to interact with AI systems, staff training, and change management, which is necessary to overcome any resistance to working with AI systems to create a symbiosis.

Research Questions

- How can AI improve operational risk management at Taif International Airport?
- What are the benefits and challenges of AI in aviation risk management?

Hypotheses of the Study

Incorporating artificial intelligence (AI) in the operation of Taif International Airport ORM will create tremendous value in the safety, efficiency, and effectiveness of operations. With the help of many datasets taken from the operations occurring in various airports, artificial intelligence applications may predict when maintenance is needed, which flights should be scheduled, and many other aspects for creating the best conditions for passengers. For instance, through AI, one can know that a specific piece of equipment must be repaired because it is about to break, and one can then take the necessary precautions. However, AI

can schedule employees in such a manner that it can enhance resource capacity, reduce time for passengers to wait, improve the quality of service, etc., based on flight and passenger traffic. The following outlines how AI has helped to minimize risks and transform the airports' functions in the modern world.

Previous Studies

Operational Risk Management (ORM) in the aviation industry is a methodical approach to making operating decisions to minimize risks and resultant accidents, loss or damage to property and equipment, and loss of lives and health of all the parties involved (Deming, 2022). It means identifying the potential hazards, evaluating their associated risks, and controlling them by taking necessary measures to reduce the likelihood or severity of the adverse events. Unlike reactive approaches, dealing with problems after they occur, ORM is proactive and tries to decrease the potential effect such hazards may have on human life and property before they occur. ORM is proactive, resulting in regulatory compliance, improved operational efficiency, and breeding a safer and more resilient future for the aviation industry. An effective ORM program is an ongoing practice of identifying risk, assessing risk, measuring risk, mitigating risk, implementing control, and monitoring risk.

The key risk factors in airport operations are the various interactions between people and technology, the operational context in which aviation activities are performed, and external threats, namely cyberattacks. Such operational risks pertain to financial loss due to the interruption of operations, damage to the company's reputation after a cyber attack, and fines for noncompliance with regulatory requirements on the results of failed audits.

According to Chen et al. (2025), addressing high-risk categories of occurrences (HRCs) is important to reduce the risk of fatalities. An effective operational risk management program

is ahead of the risks by making the right decisions at the right level, preventing the risk from becoming a reality. Risk Management aims to identify, assess, and manage risks associated with hazards to flight operations systematically and formally to manage the risks within acceptable safety levels.

AI Applications in the Aviation Industry

AI predictive maintenance in aviation is based on the application of AI technology to process large scales of data collected from aircraft operational processes to predict upcoming maintenance, minimize downtime, and ensure maximum efficiency. With historical data recorded and real-time sensor inputs provided by aircraft, AI algorithms can identify patterns and detect potential mechanical problems before they worsen (Braun, 2024). By taking a proactive stance, airlines can plan maintenance tasks, minimizing the probability of unplanned delays and decreasing the repair cost. With modern aircraft, AI systems comb through vast volumes of data generated by the aircraft, like engine diagnostics and in-flight performance indicators, and they can identify when maintenance will need maintenance and where so airlines can perform maintenance proactively without having planes grounded. By looking at massive datasets derived from aircraft systems, sensors, and historical maintenance records, AI algorithms can proactively predict issues such as equipment failures and maintenance needs with high accuracy, cutting down on unscheduled maintenance and reducing aircraft downtime. One example is a major airline that once had many unplanned maintenance downtimes that cost millions. Still, by integrating AI analytics on operational data gathered from aircraft sensors, they made highly accurate part failure predictions, which helped reduce unplanned maintenance downtime by 30%. A key driver for the aircraft predictive maintenance market is the

aviation industry's focus on cost efficiency and downtime reduction, and it is expected to grow at a compound annual growth rate (CAGR) of 5.20% between 2023 and 2030 (Grand View Research. (n.d.).

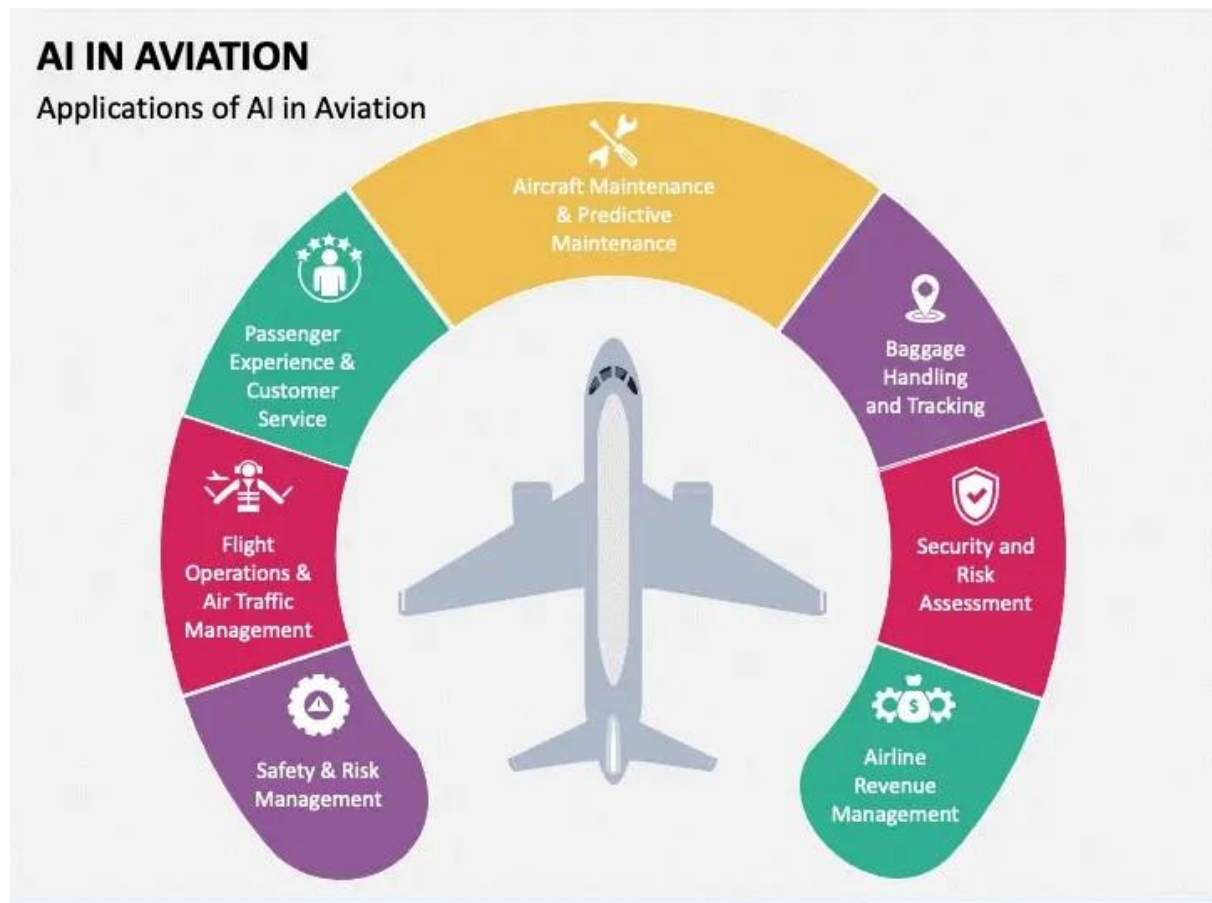


Figure 1: AI Applications in the Aviation Industry

According to Lingrui and Xin (2024), AI aids in route optimization, fuel management, and even autonomous flight control in flight operations. Live weather, air traffic, and fuel efficiency data are analyzed by AI algorithms, which then suggest the best flight paths, helping airlines reduce fuel use and lower emissions. AI systems can predict exact fuel requirements, taking into account the payload and weather, increasing fuel efficiency and

reducing operational costs. Other than that, AI also improves autopilot systems, which help keep altitudes, speed, and course, and in the future, AI could be used for entirely autonomous cargo aircraft. Through predictive maintenance, airlines gain actionable insights to streamline their maintenance processes, avoiding any disruption in flight schedules, and the capability to predict and prevent component failure decreases the costly delays and cancellations, allowing planes to stay in the air and passengers on time. With AI data analytics, we turn unstructured data into data-driven decisions and create an ecosystem where every decision is data-backed.

AI in Airport Operations and Risk Control

AI-based surveillance systems improve airport security through real-time monitoring and analysis of passenger's behavior and the airport environment. With AI video analytics, security can be alerted immediately if there is unusual activity, including unattended bags, security breaches, or suspicious movements. These systems use anomaly detection algorithms to find unaccompanied checked baggage that exhibits menacing features based on patterns. These are compared against a database of known threats to determine items that deviate from the norm and need further inspection. These AI algorithms monitor airport areas through cameras, identify and track suspicious objects or persons, and send staff immediate alerts of access violations or odd behavior. AI can learn and spot abnormal behavior to help security control room operators make timely, correct operation decisions. For instance, Punta Gorda Airport (PGD) has introduced an AI-based secure access monitoring system that detects 'piggybacking' or 'tailgating' in secure entrances and thereby increases its accuracy of detecting the incident and reducing the requirement of 24/7 manning at the airport (Hakimo.ai. (n.d.)). Generative AI is capable of real-time anomaly detection by continuously monitoring live data from baggage and security systems, supports decision-making promptly, and helps to improve overall operations at airports. AI

video analytics also monitors and analyzes baggage movement on conveyor belts, counting items accurately and enabling efficiency and security while handling the baggage.

It optimizes flight routes, predicts potential conflicts, and improves the ATM's efficiency.

AI algorithms can suggest the best flight paths by analyzing real-time data on weather, air traffic, and aircraft performance, saving fuel and reducing airline emissions. By predicting exact fuel requirements according to payload and the weather, AI systems also help improve fuel efficiency and operational costs. AI also helps autopilot systems maintain altitude, speed, and course for future AI-driven self-flying cargo aircraft (Abonomi et al., 2022). In addition, AI can manage airport parking lots by linking license plate info with time-stamped ticketing data and sending video alerts of potential problems. AI in ATMs is integrated to make flights safer and secure and offer a more pleasant passenger experience by reducing delays and optimizing airport resources.

Challenges of AI Adoption in Aviation Risk Management

Data privacy and security concerns are some of the main problems in adopting AI in aviation risk management, especially for an airport such as Taif International Airport (Ali et al., 2023). Sensitive information, including passenger data, flight details, operational details, and maintenance records, is of high volume in aviation. Since this data is used in the proper functioning of an AI system, its security and privacy are critical. The airport is also at risk of data breaches due to cybersecurity threats that can lead to breaches of passenger privacy, disruption of operations, and negatively impact the airport's reputation. Security protocols must be implemented to ensure that the information is protected through encryption and that access is restricted to authorized personnel. The information is checked for compliance with the set data protection regulation laws. Furthermore, with AI systems

targeted as cyber threats, security specialists must ensure that an AI model and its data feed are protected from tampering threats, data poisoning, and unauthorized access (Emanuilov & Dheu, 2021). These data privacy and security issues should be considered as a way of building confidence in AI systems and using AI in managing aviation risks.

However, there are also some regulations and ethical issues that dictate whether or not AI can be implemented for aviation risk management. Airlines are under much pressure to meet high safety and operational requirements. Implementing AI technologies to address these regulations can be challenging because some current frameworks are insufficient in addressing AI systems' unique characteristics (Ali et al., 2023). The regulatory authorities should, therefore, develop policies and strategies for using AI solutions in aviation that enhance safety whilst encouraging innovation. Nonetheless, the following concerns, such as algorithmic bias and the absence of transparency, need to be addressed to ensure AI systems are used fairly and appropriately. For instance, the EU AI Act categorizes AI systems based on risk levels and suggests that high-risk AI should be tightly regulated and should disclose their existence (Ellis et al., 2023). Moreover, there is a need for safety measures, cooperation between industries and organizations, and gradual implementation of the projects (for example, the Roadmap for Artificial Intelligence Safety Assurance by the FAA). Because the regulatory process for AI and the ethical consideration of their requirements are somewhat nuanced and multifaceted, steering this landscape is a community effort involving the industry, the authorities, and other specialists in AI.

AI bias and interpretability pose additional challenges to AI adoption in aviation risk management. Should there be a bias within the data that the AI system is trained on, this 'bias' can be escalated and further manifested in the result. AI systems' reliability is achieved by making systems accountable and explaining how the particular decision was made. Testing and validating an AI system is crucial to ensure that it performs the expected

function when exposed to certain conditions and makes non-biased decisions. It is important to stress that there is no safety-critical AI at the present moment, mainly because of the lack of standards and regulations in this field. Modern AI systems' characteristics include data intensity, opaqueness, and non-deterministic, which do not fit well with traditional safety certification processes. Therefore, identifying the AI bias and enhancing the interpretability of the AI systems in order to build trust in the use of AI in aviation risk management is crucial.

Research Gap

However, there is a research gap in the specific studies that are carried out on AI-based risk management in Middle Eastern airports, particularly in the practical work and legal and regulatory conditions of Taif International Airport. Even though the application of AI is revolutionizing every sector across the MENA region, and the use of AI in airports is gaining more recognition, there is a gap between the two (Tsiakalos, 2024). This is because most of the literature available to the general public concerns developed countries or aviation without considering Middle Eastern airlines. This is further compounded by the fact that the region's security and regulatory factors are quite different from other traditional markets. In addition, there is a lack of research on the impact of AI on risk management in airports in the Middle East, which implies that further research should be conducted to provide strategies and policies that should be applied in the region.

Theoretical Framework of the Study

AI technologies are revolutionizing risk management across several industries, but especially in aviation, to provide unmatched abilities in data analysis, pattern recognition, and predictive modeling, all indispensable drivers to boost the safety and operational efficiency of an airport such as Taif International Airport. Various Machine Learning (ML)

algorithms, spanning from supervised learning (i.e., regression, classification) to unsupervised learning (i.e., clustering, dimensionality reduction), are being used to infer patterns in enormous and heterogeneous datasets (Chakraborty et al., 2022). Historical flight data (altitude, speed, location), maintenance records (component failure rates, repair logs), weather patterns (wind speed, visibility, precipitation), and sensor data from airport infrastructure (runway conditions, equipment status) are some of the data available for analysis. For example, ML models can forecast in advance which equipment on an aircraft will fail with higher accuracy than conventional means, thus decreasing the likelihood of equipment failure that could cause delays or safety incidents. Natural language processing (NLP) is important because AI systems can only extract meaningful information from unstructured text data like pilot communications, maintenance reports, and incident logs (Yang & Huang, 2023). The ability to automatically analyze qualitative data allows for identifying recurring issues or safety hazards otherwise missed. Real-time monitoring of airport operations is carried out by using computer vision for tasks like detecting anomalies on the runways (like debris, a crack, etc.), enhanced security with facial recognition and object detection, and ensuring the safety protocols are followed in ground operations. Together, these AI technologies facilitate automated risk assessment processes, enhance situational awareness, and aid in implementing proactive and targeted risk mitigation strategies critical to safe and efficient airport operations.

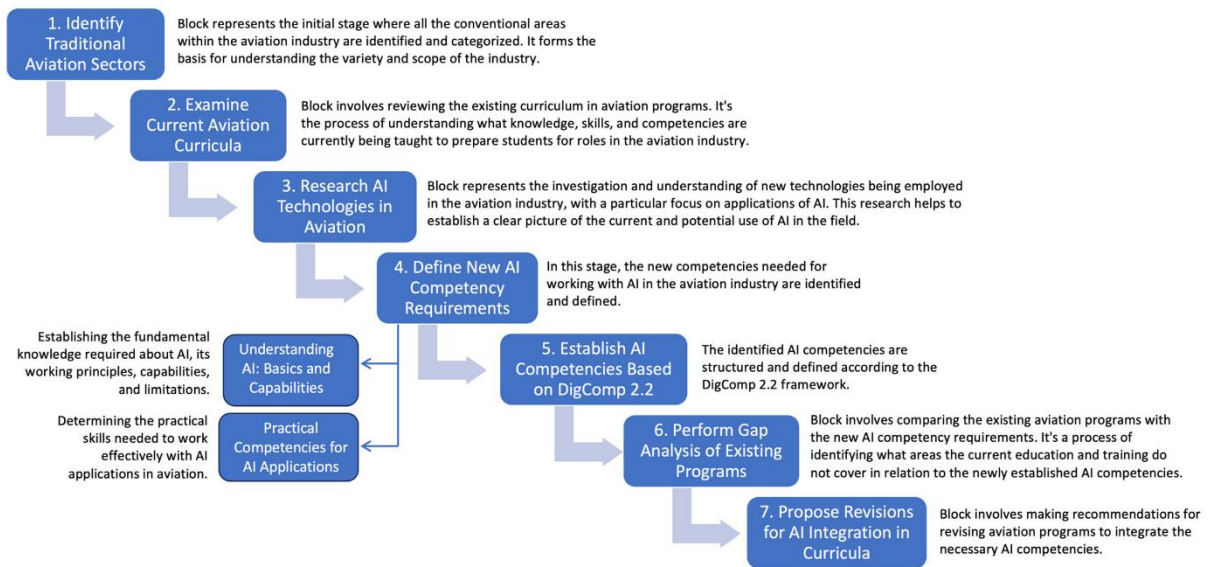


Figure 2: Artificial Intelligence in Aviation

The AI-driven risk assessment models are transforming the way organizations think about risk management and are offering more accuracy in understanding the threats and vulnerabilities, timeliness in doing so, as well as adaptivity that makes the strongest case for airports like Taif International Airport to improve its safety and operational resilience. These models rely on algorithms such as deep learning and neural networks to process extensive data, find obscure patterns and correlations, and, more effectively, assess the possibility and magnitude of risk situations than traditional models can. It can be trained to show how it is possible to train an AI model to monitor the aircraft's flow and predict the likelihood of a runway incursion, given the traffic load, weather factors, and pilots' behaviour. From the point of view of risk assessment, the application of AI is a systematic and long-term process that places an airport at the forefront of new threats and can flexibly respond to changes in the context of activity. These advancements are needed for airports like Taif International Airport to proactively identify and manage risks, be safe, and, more importantly, improve operational efficiency.

Methodology and Research Methods

This research paper shall discuss integrating artificial intelligence (AI) within operational risk management (ORM) using Taif International Airport as a case study. The case study method is suitable for investigating complex issues in a real-life setting to identify the problems, possibilities, and effects of implementing AI in a given airport setting. Since Taif International Airport is a greenfield airport built as a PPP project, it is the perfect case for analyzing how AI-driven ORM can be implemented from the ground up. To sum up, safe and reliable operation is needed to achieve the goal of 2.5 million passengers per year by 2030; this means that efficient and advanced Risk Management should be applied; therefore, using the case study approach will provide a comprehensive understanding of how the AI will enhance ORM practices about Taif International Airport's operation environment, risk assessment, and strategy.

Mixed-Methods Research: Qualitative and Quantitative

Combining both qualitative and quantitative paradigms will help gain an extensive and inclusive understanding and ensure a holistic view of the phenomenon under study by using both qualitative and quantitative research tools (Bieńkowska & Sikorsk, 2024). This will allow triangulation to substantiate the study findings, hence the research study's validity and reliability. Quantitative methods will address objective questions to gain factual information about the current state of ORM at Taif International Airport, and statistical analysis will be used to analyze the collected data. On the other hand, qualitative data will be utilized to determine the effectiveness of the ORM intervention related to the AIs and establish the correlations and statistical significance regarding the qualitative findings. Through quantitative and qualitative findings, this research will give a comprehensive and methodologically sound investigation of AI in ORM at Taif International Airport.

Research Tools

In this thesis, both primary and secondary research techniques will be adopted in order to collect the necessary data. The primary data collection technique will involve interviews with various stakeholders involved in ORM at Taif International Airport, airport risk managers, artificial intelligence specialists, aviation safety officers, and other operational personnel. These interviews shall enable me to assess the current ORM measures employed at the airport, ORM's challenges in managing operational risks, the possibilities of applying AI to manage the challenges faced, and AI's perceived advantages and disadvantages. Interviews will be semi-structured to allow for flexibility in finding interesting emerging themes and to provide in-depth information on particular topics of interest. Interview questions will be designed to obtain information on the following areas.

The current situation of ORM processes and practices is in Taif International Airport.

Identification of key operational risks and their potential impact

Awareness and understanding of AI technologies and their potential applications in ORM

Benefits and challenges of AI adoption in ORM that are perceived.

What training and organizational support is required to implement AI successfully, and what data infrastructure is necessary for AI Python projects?

Issues concerning the use of AI in ORM in terms of ethical and regulatory considerations

Secondary Data: Literature Review and Industry Reports

Secondary data will be collected using a comprehensive review of existing literature, industry reports, and airport documentation. The literature review will provide a theoretical

background to the study, whereby the existing knowledge of AI in ORM will be explored, and best practices and lessons learned from other airports will be identified. Industry reports and airport documentation (including safety reports, incident logs, and risk assessments) will provide good data about the operational risks faced at Taif International Airport and how the current ORM practices affect the operation. Secondary data will supplement the primary data and provide additional context to the research topic. Other sources for detecting the best tools, like MindBridge's AI platform that continuously analyzes transaction data and automates reviews and assessments to identify known and unknown risks, can also serve as a secondary resource.

Sampling Strategy

To select the interview participants, we will use a purposive sampling strategy so that the sample provides participants with relevant expertise and experience in ORM and AI. The sample will consist of:

The airport risk managers: These individuals manage the ORM in Taif International Airport and will provide information on the airport's risk profile, current ORM practices, and strategic goals.

Professional in AI technologies and applications to risk management: AI experts: People who know AI technology applications in risk management in aviation and the possibilities (benefits and challenges) of using AI in aviation.

Personnel responsible for ensuring Taif International Airport's safety, giving an opinion of the risks to which airport operations are exposed and the efficiency of the current safety measures.

Air traffic control, ground handling, and security employees in various airport operations can contribute to practical challenges of operational risk management on the ground.

The sample size will be set according to the principle of data saturation because data collection should continue until no new insights or themes are identified as a result of the interviews. Given the uniqueness of the research topic, this study will involve a sample size of 15 to 20 participants, which will be adequate to achieve data saturation and include various perspectives of stakeholders and their experiences. All interview participants will be required to give their informed consent voluntarily.

Data Analysis Techniques

Qualitative

The interview data will be analyzed using qualitative data analysis technique, thematic analysis, whereby reoccurring themes and patterns will be identified in the data¹. A few steps will be taken when conducting a thematic analysis.

Initial Interaction: The researcher will reread the transcripts and make initial notes and observations.

The researcher will systematically code the interview transcripts by assigning labels or codes to text segments relevant to the research questions. The coding will be iterative because the codes will be refined and revised as new understanding comes from the data.

Code grouping: The researcher will organize the codes into broader themes, allowing the researcher to see overarching patterns and relationships between the data. The themes will be developed based on the research questions and theory of the study.

Refining the themes: The researcher will refine them to ensure they are coherent, internally consistent, and data-driven. The themes will be named and defined, and illustrative quotes from the interview transcripts will be chosen to exemplify the theme.

Accounts: The researcher will also provide a narrative account of the findings, including themes and interview data, to support the conclusions. The narrative structure will be based on the research questions to give a detailed and nuanced view of AI's role in ORM at Taif International Airport.

Quantitative

Quantitative data (e.g., performance metrics and risk assessments) will be analyzed using statistical methods to help evaluate the effectiveness of AI-driven ORM interventions. The specific statistical methods will vary depending on the type of data and the research questions they can address. Descriptive statistics will describe data characteristics, i.e., means, standard deviations, frequencies, etc. A comparison of the performance of AI-driven ORM interventions with traditional ORM practices will be made using inferential statistics like t-tests and ANOVA. This will be achieved through regression analysis of the relationship between AI adoption and key performance indicators (safety incidents and operational efficiency). This will be presented in tables and figures and give a clear and concise indication to prove the research findings due to the quantitative analysis results.

Ethical Considerations

Ethical considerations will precede this research on AI implementation in operational risk management at Taif International Airport, particularly informed consent and data protection. The research will ensure informed consent from all participants (airport risk managers, AI experts, and aviation safety officers). This will demand an explicit presentation of the research goals, means of data collection, possible hazards and rewards of participation, and steps taken to preserve privacy. Participants will be voluntarily involved in this study and be informed that they have the right to withdraw from this study at any time without consequence.

Data protection measures will be critical to protect the privacy and security of the sensitive information collected. Due to the amount of personal and operational data handled by the aviation sector, the research will apply strong protocols for preventing data breaches and unauthorized access. This will mean that the data will be encrypted when stored and transmitted; only authorised staff should have access to the data, and the data must be stripped of any personal identifiers. All the provisions of the data protection laws will be .complied with

Secondly, transparency and accountability for using the developed AI systems will be critical in developing trust and promoting the proper use of AI. Potential sources of bias used in the algorithms shall be investigated, and measures to counter the biases shall also be implemented. The project will ensure that ethical principles like fairness and accountability are followed during the study. Considering the above moral concerns, this research will allow AI's safe and ethical deployment in Taif International Airport's risk .management

This research, therefore, focuses on the operational risks of Taif International Airport but does not include cybersecurity risks. Thus, by narrowing down the focus, it is possible to consider how AI can address other routine operational issues, such as ground navigation mistakes, runway infringements, or equipment malfunction.. Nevertheless, cybersecurity is undoubtedly a serious concern for modern airports. It requires separate and equally comprehensive study for its unique nature, technical complexities, and specific risk reduction tactics in the context of its features. Focusing on operational risks provides a means to analyze how AI can strengthen safety, efficiency, and overall operational resilience at Taif International Airport in this particular context.

Limitations of the Study

The limitation of this study is that it takes place in only one operation area, the Taif International Airport. This approach allows for a rich understanding of the airport's context, risk, and AI implementation barriers and limits the generalization of the results to other airports. The use of AI solutions in airports can only be efficient if they fit the size of the airport, the traffic it receives, the infrastructure it has, and the organizational culture of the airport. Nevertheless, the conclusions derived from this research may be effectively used as a basis for other airports with similar objectives of using artificial intelligence. It can help to define their issues and to design AI-based approaches to overcome them. It also contributes to the understanding of how AI may be applied for aviation risk management and creates the base for further research regarding the application of AI in airports.

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