

# Analyzing Delays in Airport Operations: The Causes and How it's Affected by Flight Operation Officers, Aircraft Mechanics, and Ground Crew in Major International Airports

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## ABSTRACT

This study aimed to analyze airport operations, identify the causes of delays, and examine how these delays are influenced by personnel involved in airside operations. A mixed-method approach was utilized, gathering data from 14 respondents, including Flight Operation Officers, Aircraft Mechanics, and Ground Crew. Surveys were used to examine and compare responses, which informed the development of interview questionnaires. The results revealed that delays result from a cascade of events, with factors such as weather, maintenance, and premeditated delays serving as root causes. Considering human factors, the study found that while aviation personnel are well-trained, limitations such as inadequate facilities and high operational loads without sufficient manpower may lead to minor deviations that accumulate into significant delays. The study suggests that clear communication of processes between airports, airlines, and aviation personnel regarding premeditated delays caused by uncontrollable factors may help mitigate their impact on scheduled operations. The findings emphasize the importance of understanding and managing the effects of delays rather than attempting to eliminate them entirely, as delays can serve as a mechanism to balance safety, operational schedules, and passenger satisfaction.

**Keywords:** Airport Operations, Analysis, Causes, Delays, Major International Airport

## INTRODUCTION

Air transportation enables global connectivity; however, persistent challenges such as flight delays continue to affect both passengers and airlines. Inefficient airport operations during arrivals often lead to congestion and delays, disrupting schedules, increasing operational costs, and straining airport resources. A comprehensive analysis of these challenges is essential for airports to make informed decisions and implement effective solutions. As congestion increases, the adoption of improved operational strategies becomes necessary to enhance airport efficiency and the overall passenger experience.

Flight delays are among the most significant operational challenges facing major international airports, affecting airport efficiency, passenger satisfaction, and the global aviation network. Despite advancements in technology and management practices, delays persist due to a combination of human, environmental, and technical factors. A deeper understanding of these contributing factors is required to achieve more efficient flight operations. Human factors, in particular, are a primary cause of operational delays, as individual performance and decision-making have a substantial impact on flight outcomes. Problems, including pilot or crew scheduling, come into conflict. The scheduling of aircraft turnarounds is a consequence of both the operational policies and the scheduling strategies of an airline ( Yakun C. et al., 2019). Macro-level factors, such as temporal variables, seasonal effects, airline and airport are widely used as inputs for delay prediction models created an adaptive network model based on the macro level factors, such as origin of the departure flight, departure time, scheduled arrival time to predict flight delays and the predictions were used as inputs for a fuzzy decision-making system to schedule aircraft landing (Qiang Li et al., 2021). Also, air traffic controller workload, poor training, or loss of communication, strikes by workers, manpower shortages, and

mismanagement of ground operations tend to increase the effect of human mistakes and directly lead to delays, making it more crucial to have effective coordination

among employees at every level of airline operations. Weather plays an important role in how flights are managed and operated; it can sometimes turn travel plans upside down. When storms roll in, a thick layer of fog spreads across the runway, or strong winds whip through the area, airports regularly have to put safety first by stopping or delaying operations. Aircraft might need to taxi more slowly, or sometimes runways have to close temporarily. Flight delays can be frustrating for passengers, causing longer waits and more uncertainty. The technical factor covers aircraft and airport systems that support flights, such as maintenance, navigation radar, runway lighting, and baggage handling technology. When any of these systems experience issues, flights may be delayed, causing significant inconvenience for passengers.

In the 1920s, minimal air traffic allowed for informal procedures to manage a small number of aircraft. By the 1950s and 1960s, demand for air travel surged, placing unprecedented pressure on airports and airspace. This led to the development of more sophisticated Air Traffic Control (ATC) systems, including radar and centralized traffic management. As flight numbers increased, congestion and delays became common, and airports struggled to optimize capacity. Arrival processes can immediately impact air traffic networks, leading to constraints and delay propagation (Alvaro et al., 2019). In the late 1980s and 1990s, safety and efficiency management became central to aviation, yet ATC-related delays persisted, especially during peak periods. Today, ATC delays remain a significant challenge due to the need to balance safety, capacity, and efficiency in a busy industry. Efforts in Europe have focused on addressing air traffic flow problems to reduce delays while maintaining performance (Nikola et al., 2017). While ATC is essential for safe and effective flight operations, it can also contribute to increased flight delays.

Identifying the root causes of flight delays within the air transport system is essential. Delays are influenced by factors such as departure performance, origin airport characteristics, and gate processes, indicating that disruptions often arise from multiple operational points rather than a single source. Delays are significantly affected by factors including departure performance (Mokhtarimousavi and Mehrabi, 2023). Aside from the possibility of delays due to clear reasons like weather and airport capacity, it is also possible due to indirect reasons like congestion created by earlier flights that accumulate and increase potency over time. (Wang et al., 2022). A majority of delay chains originate at main hub airports, and weather disturbances and delayed aircraft arrival are the most common causes that propagate delays across the network. (Hotle & Atallah, 2021). Flight delays seldom occur in isolation; rather, they arise from a complex network of interrelated factors that require comprehensive solutions. Identifying the underlying causes of these delays is crucial for developing targeted interventions that minimize disruptions and mitigate cascading effects throughout the air traffic system. Research frequently examines the influence of weather and airport conditions on flight delays and airport performance. For example, adverse weather conditions such as storms or low visibility often result in arrival delays and decreased airport throughput. Some studies utilize machine-learning and deep learning techniques to predict delays by analyzing weather impacts and additional variables (Kawwunruen et al., 2021). Other research focuses on airport size, connecting passenger volumes, and the network dynamics of delay propagation and mitigation among airports (Attalah & Hotel, 2022). Furthermore, emerging technologies such as multi-agent planning models and wind Doppler LIDARS have been proposed to transform delay management and airport operations (Thobois & Cariou, 2015).

Delays at airport terminals often cause problems for passengers, ground crew, and airport staff because they disrupt flight schedules and operations. Researchers found that delays are mainly caused by human, environmental, and technical factors. To address these issues, new strategies have been developed to manage congestion in airport operations. Since delays impact passengers, airlines, and staff, deep learning models are now used to make flight delay predictions more accurate.

## Background of the Study

The Philippines hosts major international airports that have faced significant infrastructure challenges since at least 2008, as reported by The Inquirer. Despite growing demand for air travel, the airport and its terminals have remained largely unchanged, affecting passengers, ground crew, and airport personnel. The quality of

airport infrastructure shapes their satisfaction, including terminal facilities, accessibility, safety, security, amenities, and services. Comfort during delays, efficient queue management, and staff communication are critical to the passenger experience. This study aims to offer solutions by analyzing the main reasons of flight delays in airport operations and suggesting possible solutions to airport personnel. The suggested methods and improvements will reduce flight delays in airport operations, providing advantages for passengers, ground crew, and airport personnel. This will enhance airport efficiency and competitiveness as well. Therefore, this study has the potential to improve operational efficiency and elevate passenger experience. Considered as the main gateway of the Philippines for foreign and local travelers, flight delays have been a prominent problem that offers significant operational challenges. The most significant flight delays happen at four terminals in Pasay and Parañaque, which are Terminal 1, which serves primarily International flights; Terminal 2, which serves partial domestic and partial international flights; Terminal 3, which serves partial local and partial foreign flights; and Terminal 4, which only has small domestic carriers. The major international airport in Metro Manila is the busiest airport in the country, servicing millions of travelers every year. However, due to its limited runway availability and dense passenger load, congestion is generally due to sheer volume in both of the dimensions, creating a size-to-capacity ratio that creates extremely severe delays. Spatial interactions between people through goods or information are neglected in terms of predicting operational delays (Kaiquan CAI., 2022). Delays in airport operations may occur due to human error, environmental, machine, and even construction-related factors (Al-Ghzawi et al., 2023)

### Theoretical Framework

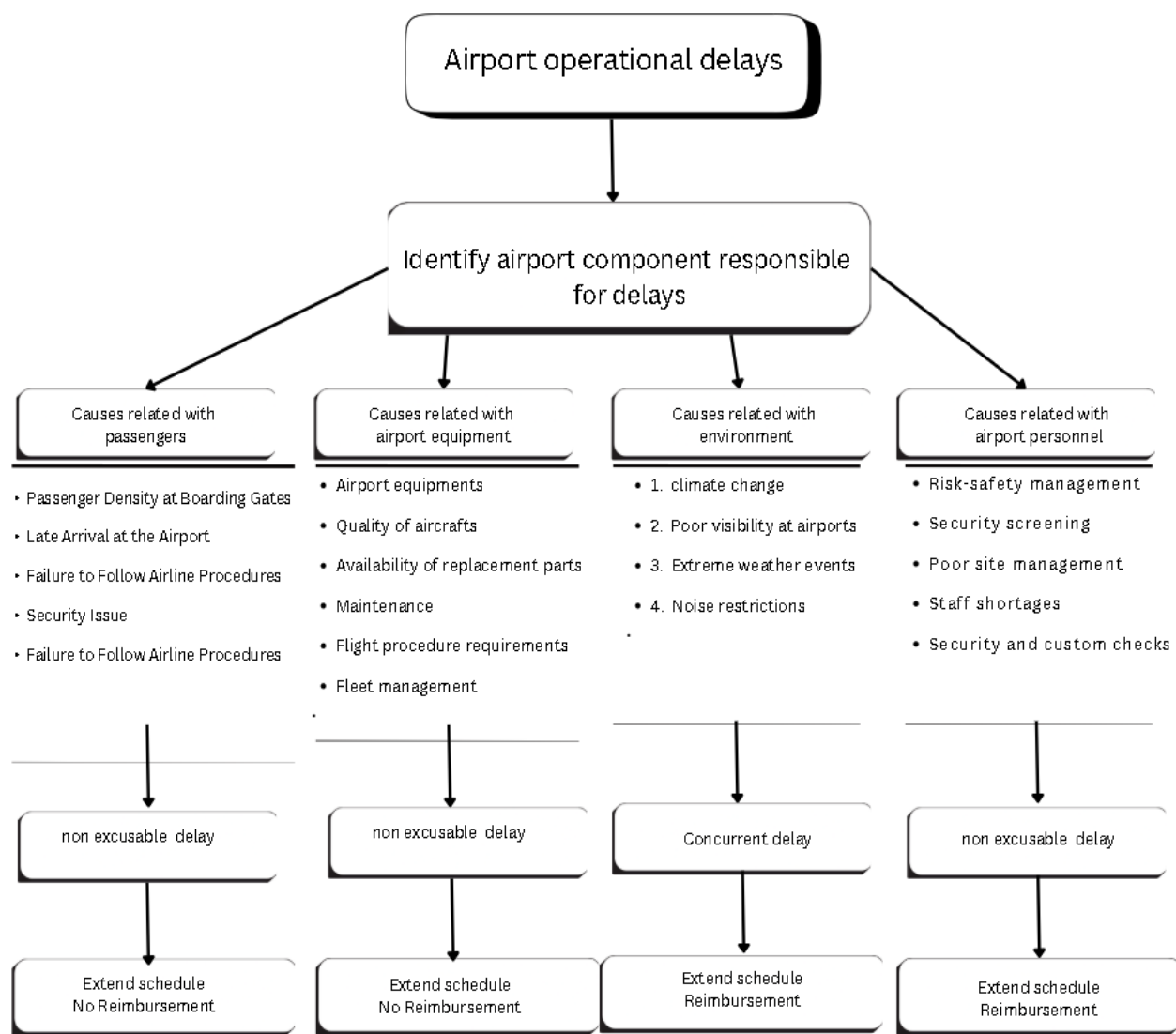


Fig. 1: Delay theoretical framework

The research was based on the process for determining causality of airport operational delays, which is guided by the delay theoretical framework (Ghenbasha et al., 2016). Using this model on issues concerning airport capacity, passenger service quality, and safety degradation intensified operational delays (Chen et al. 2022). Categorizing them mainly by passengers, airport personnel, airport equipment, and environment, then determining if it causes excusable delays, non-excusable delays, and concurrent delays.

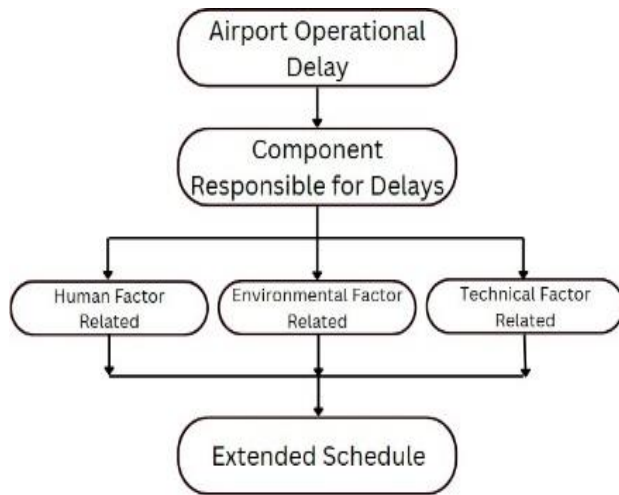


Fig. 2: Paradigm on Airport Operational Delay that results in Extended Schedules

### Conceptual Framework

Delays in airport operations are one of the most prominent problems for major international airport terminals, yet their causes have not been clearly defined over the years, despite the consistent growth in air travel demand. This conceptual framework provides a clear insight into the causes of delays. The researchers developed a conceptual framework using variables related to passengers, airport equipment, the environment, and airport personnel, based on the theoretical framework. These variables connect the causes of airport delays to how they are addressed in airport operations.

### Statement of the Problem

This study aimed to analyze delays and causes in Airport Operations and how it affects Flight Operations Officers, Airport Personnel, and Ground Crew in Major International Airports. It focuses on human, environmental, and technical factors that affect flight delays and provides strategic decisions for improvements. Specifically, the study sought the answers to the following questions:

1. What are the primary operational factors in Major International Airports that contribute to flight delays concerning:
  - a. Human Factors;
  - b. Environmental Factors; and
  - c. Technical Factors?
2. How are the ATCs affecting the delay period between flights?
3. Where do flight delays primarily originate from?
4. Is there a significant difference between the causality & severity of delays caused by human, environmental, and technical factors?
5. Based on the informant's findings of the study, what are the factors that influence the origin of delays in

airport operations?

## Hypothesis

**Null Hypothesis:** There is no significant difference between the causality and severity of delays caused by human factor, environmental factor, and technical factor.

## Significance of the Study

6. **Passengers:** Passengers may benefit from this study as it identifies the root causes of flight delays of Major International Airports situated in Manila, which directly impact their travel experience. By understanding these factors, stakeholders can implement solutions to improve scheduling efficiency and enhance comfort during waiting periods.
7. **Ground Crews:** Ground crews may benefit from the study's analysis of how human, technical, and environmental factors contribute to delays that affect workload and productivity. Clear insights into these issues may help reduce stress, improve coordination, and enhance operational efficiency.
8. **Air Traffic Controllers:** Air traffic controllers play a crucial role in maintaining the smooth flow of flights and ensuring airport safety. This study is significant for them as it provides a deeper understanding of the factors causing delays, enabling improved coordination, decision-making, and more effective air traffic management.
9. **Airport Personnel:** The research offers airport personnel an in-depth analysis of operational issues, including human, environmental, and technical factors that lead to delays. The findings can inform policy decisions, staff deployment, infrastructure improvements, and the implementation of more efficient airport processes.
10. **Future Researchers:** This study serves as a valuable reference for future researchers interested in airport operations, delay management, or passenger experience in Major International Airports situated in Manila. It provides relevant data, insights, and recommendations to support the development of subsequent research.

## METHODOLOGY

### Research Design

This research employs a mixed-methods approach that is mainly quantitative through a structured survey questionnaire to collect measurable data from Flight Operations Officers, Air Traffic Controllers, and Ground Crew. The intended quantitative analysis would uncover the most significant human, environmental, and technical factors contributing to a flight delay, while qualitative analysis is integrated into the study through the secondary literature related to how delays affect the operational efficiency of the airport. A combination of both methods makes for a comprehensive analysis of the causes of airport delays and their effects on operations.

### Respondent

This study employed Slovin's formula to determine the number of respondents from 181 employees who are working in Major International Airports. With respect to the time constraint given, the study also used an acceptable rate of response ranging at 10%-15% which aligns with Padya (2020) that emphasizes acceptable survey response rates have no universal percentage that defines adequacy while being dependent on population and context resulting in a minimum of 13 respondents for accurate data representation. The primary objective is to gather demographic data such as sex and occupation.

Sex	Frequency	Percent
Male	9	64.29
Female	5	35.71
<b>Total</b>	<b>14</b>	<b>100.00</b>

Table 1: Frequency and Distribution of the Sex Representation of the respondents

Table 1 shows that the majority of respondents, based on their sex, are male, accounting for a total of 64.29% of the sample.

Occupation	Frequency	Percent
Flight Operation Officer	7	50.00
Aircraft Mechanic	4	28.57
Ground Crew	3	21.43
<b>Total</b>	<b>14</b>	<b>100.00</b>

Table 2: Frequency and Distribution of the Occupation Representation of the respondents

Table 2 shows that the majority of respondents, based on their occupation, are Flight Operation Officers, accounting for a total of 50.00% of the sample.

### Settings

The study on analyzing delays in airport operations utilized a mixed-method approach to understand the causes and how they are affected by Flight Operation Officers, Aircraft Mechanics, and Ground Crew in major international airports. This study explored the current processes practiced at major international airports and assess their effectiveness while using the gathered data to create surveys for the targeted respondents to confirm the statements presented to them.

The study aimed to assess the experiences of Flight Operation Officers, Aircraft Mechanics, and Ground Crew and use the data gathered as a reference to compare and contrast information from related literature. Respondents were limited to aviation professionals who are Flight Operation Officers, Aircraft Mechanics, and Ground Crew who operate, have operated, or have experience in areas such as the terminal, apron, and runway. As such, ATCs were not included as respondents in the survey because the study focused on airside operations that occur on the ground, while ATC decisions indirectly influence these operations. The study did not evaluate ATC performance but examined how ATC-related factors affect the included personnel groups.

### Instrumentation

The researchers conducted surveys using a combination of questionnaires and interviews. The researcher-made survey emphasized different areas that allowed the researchers to discern and differentiate factors such as human, environmental, and technical. These factors aligned with the purpose of the study: to analyze delays in airport operations, identify their causes, and determine how they are affected by Flight Operation Officers, Aircraft Mechanics, and Ground Crew. Understanding these perspectives allowed airport operations to be evaluated and improved through appropriate recommendations. The survey was also reviewed and critiqued, with recommendations applied by the chairperson of the Air Transportation department, an alumnus of an aeronautical institution with field experience, and a Flight Operation Officer.

The questionnaire was composed of positive statements aligned with the intention of clarifying and differentiating experiences from established facts. A pilot test, which passed Cronbach’s Alpha, was conducted with students as respondents to improve the quality and relevance of the statements. The final survey included revised statements to provide deeper insight into the causes of delays in airport operations and how they affect the aviation personnel mentioned earlier. Interviews were conducted with three informants regarding the

questions identified as significant from the survey results to gather and further define their insights and recommendations on the matter.

### Data Analysis

Scale	Range	Adjectival Interpretation
4	3.25-4.00	Strongly Agree
3	2.50-3.24	Agree
2	1.75-2.49	Disagree
1	1.00-1.74	Strongly Disagree

Table 3: Range of Scales

The researchers utilized both qualitative and quantitative methodologies to analyze delays in airport operations. The study was approached using a descriptive framework, where the experiences of key personnel, such as Flight Operation Officers, Aircraft Mechanics, and Ground Crew, were thoroughly analyzed through the surveys distributed to them. The researchers used the snowball method to distribute the surveys, as aviation personnel have tight schedules that require careful attention to their workload. This method ensured that the study did not interrupt or interfere with their professional duties. The results were then subjected to descriptive statistics to interpret the data and translate it into weighted means and standard deviations to discern the significance of the findings.

The survey also underwent a series of evaluations before finalization for distribution. A quantitative measure using Cronbach’s Alpha was employed to validate the reliability of the survey and ensure that the statements reflected the same underlying concept. ANOVA was then used to efficiently compare the groups and identify significant differences, which were utilized for the one-on-one interviews for further verification and analysis. Combining these methods allowed the researchers to analyze delays in airport operations and produce in-depth recommendations while highlighting valid data in summarizing the study.

The qualitative methodologies employed by the researchers included one-on-one interviews with informants who completed the survey and exhibited significant findings. Thematic analysis was used to develop and verify the statements included in the survey. The data gathered from the respondents were cross-checked with the literature as a means of verification for the analyses discussed by the researchers in the results and discussion.

### Ethical Considerations

The researchers ensure that personal information remains confidential and will be used solely to fortify the contents of the study. The data retrieved from the survey will be respected and cause no harm to any of the respondents’ health and safety at risk. Data will be stored online in a database accessible only through an organizational email; only the lead researcher will have access to the survey itself. The topics of the survey do not exhibit any questionable or uncomfortable instances that may affect the respondents. The study would not cause any defamation of any institutions or companies involved. The presence of our study would not disrupt or greatly affect any operations in the respondent's company or institution. As such, the results of the research

will aid in the respondents' institutions or company and their operations by surfacing issues disregarded or unnoticed by normal procedures.

## RESULT AND ANALYSIS

The primary operational factors in Major International Airports that contribute to flight delays are:

### Human Factors

Statement	Standard Deviation	Weighted Mean	Remarks
I underwent sufficient training or know sufficient knowledge on air and ground operations	0.51355	3.57	Strongly Agree
I am confident in the judgement of the prepared routes of Flight Operation Officers for the most efficient route taken by the aircraft.	0.51887	3.5	Strongly Agree
I have sufficient rest to perform well during disruption/overscheduling	0.91687	2.93	Agree
I notice that efficient decision-making by air traffic controllers and staff helps reduce uncertainties in arrival, departure, and taxi times.	0.49725	3.64	Strongly Agree
I am able to manage arrival and departure flights effectively even in times of tight schedule.	0.63332	3.36	Strongly Agree
Total	0.32344	3.40	Strongly Agree

Legend: 3.25-4.00 - strongly agree 2.50-3.24 - agree 1.75-2.49 - disagree 1.00-1.74 - strongly disagree

Table 1: Mean and Standard Deviation in Terms of Human Factors Environmental Factors

Statement	Standard Deviation	Weighted Mean	Remarks
I experience or witness no overcrowding during security procedures and passenger processing.	0.91387	2.29	Disagree
I often observe that weather conditions and seasonal factors strongly influence whether flights depart or arrive on time.	0.42582	3.79	Strongly Agree
I have not experienced or witnessed delays affected by heavy traffic congestion on the runways or aprons.	0.99725	1.93	Disagree
I have not experienced or observed seasonal demands of travel influence delays caused by an increase in delay in the immigration	1.10940	2.00	Disagree
I have not experienced or witnessed repeated delays toward recurring travel destinations.	1.06904	2.71	Agree
Total	0.60474	2.54	Agree

Legend: 3.25-4.00 - strongly agree 2.50-3.24 - agree 1.75-2.49 - disagree 1.00-1.74 - strongly disagree

Table 2: Mean and Standard Deviation in Terms of Environmental Factors

This section illustrates the survey results covering the influence of human factors on significant international airport delays. The findings indicate standard deviations of 0.50 to 0.89, hence low variation in responses. The weighted mean of 3.44 indicates the overall rating by the respondents that human factors are involved in efficient functioning. This implies that employees are well-trained, self-assured in making decisions, and effective in time and workload management. However, there is still a slight concern regarding adequate rest while being overworked, which influences vigilance and reliability. Aviation is about guaranteeing the safety of the operations being held on a daily basis, the survey findings also support that delays are intentional to some degree to make sure safety is properly accounted for. These findings emphasize that continuous training and effective workload management enhance operational reliability. (Mokhtarimousavi et al, 2023). Likewise, improving decision-making processes through data-informed strategies helps minimize human-related flight delays (Wang et al., 2022).

The survey results detail that seasonal demands influence the fluctuation of delays negatively regarding the environmental factors that affect flight delays. Based on the respondents collected, the standard deviation ranges from 0.40, the lowest, to 2.0, 6 the highest. Highlighting the environmental factors that affect flight delay environments in this context refer to the place where operations are conducted in relevance to aviation and its procedures. The calculated weighted mean for these aspects is 2.58, reflecting mixed responses. They generally agree that they experience overcrowding during security procedures and passenger processing, weather conditions, and seasonal factors influence travel destinations, whether flights depart on time and do not experience repeated delays toward recurring travel destinations. While there are notable concerns about the delays affected by heavy traffic congestion on the runways or aprons and seasonal demands of travel influence delays caused by an increase in delay in the immigration. These findings indicate that improving passenger flow management, staff coordination, and immigration procedures during peak periods can help reduce overcrowding and delays, while expanding runway capacity and optimizing flight schedules can further enhance overall airport efficiency and passenger experience. Bad weather and flight delays: the impact of sudden and slow onset weather events (S. Borsky et al., 2019).

### Technical Factors

Statement	Standard Deviation	Weighted Mean	Remarks
I support innovations such as: computer generated simulations for baggage handling, and loading operations to assess strengths and weaknesses	0.63332	3.64	Strongly Agree
I do not believe that delays are caused by air traffic management systems and its ability to manage scheduling.	0.82542	2.71	Agree
I have not experienced or witnessed delayed itineraries due to gate availability, or prolonged passenger wait time.	1.15073	2.36	Disagree
I have not experienced or witnessed delays due to aircraft maintenance.	1.00821	1.64	Strongly Disagree
I have not experienced or witnessed airport equipment malfunctions that slow down ground operations.	1.14114	1.93	Disagree
Total	0.61483	2.46	Disagree

Legend: 3.25-4.00 - strongly agree 2.50-3.24 - agree 1.75-2.49 - disagree 1.00-1.74 - strongly disagree

Table 3: Mean and Standard Deviation in Terms of Technical Factors

This section presents the statistical results regarding technical factors that contribute to flight delays in major international airports. Following data collection, the standard deviations ranged from 0.6, the lowest, to 1.12, the highest. The calculated weighted mean for these five statements was 2.49, with respondents mostly marking “strongly agree” and “agree.” Based on the data, the respondents strongly agreed with supporting

innovations to assess strengths or weaknesses and strongly disagreed that they had not experienced delays due to gate availability. This emphasizes the contrast in aviation professionals’ perspectives regarding this factor as a contributor to flight delays. According to the survey, innovations would assist in minimizing the necessary delays deliberately caused to ensure the safety and efficiency of procedures. The estimation and consideration of operational delays are associated with strategic airport slot scheduling decisions, with respect to multiple airport slot scheduling objectives and performance metrics (Katsigiannis et al., 2023). To address these challenges, there is a pressing need for an accurate and reliable model for predicting the impact of alternative construction plans on flight ground movement time without the need for repetitive and time-consuming simulations (Al-Ghzawi et al., 2024).

The Air Traffic Controllers effect to the delay period between flights

Statement	Standard Deviation	Weighted Mean	Remarks
I am confident in the Air Traffic Controllers ability to precisely manage the Terminal Maneuvering Area without the assistance of automation.	0.63332	3.36	Strongly Agree
I am confident that modernizing air traffic control infrastructure reduces delays and environmental impacts.	0.51887	3.50	Strongly Agree
I believe that understanding how delays form and propagate improves our ability to minimize air traffic delays.	0.51355	3.57	Strongly Agree
I have not experienced or witnessed high load operations in the terminal control area.	0.66299	1.86	Disagree
I believe that we have sufficient staff and personnel to issue clearances on time and maintain traffic flow efficiently.	1.01905	2.50	Agree
Total	0.35239	2.96	Agree

Legend: 3.25-4.00 - strongly agree 2.50-3.24 - agree 1.75-2.49 - disagree 1.00-1.74 - strongly disagree

Table 4: Mean and Standard Deviation in Terms of The Air Traffic Controllers Effect to The Delay Period Between Flights

This section discusses how air traffic controllers (ATC) affect the delay interval between flights. The findings reveal standard deviations ranging from 0.50 to 1.02, with a weighted mean of 3.04, suggesting general agreement that ATC performance has a significant impact on flight delays. The respondents expressed confidence in controllers’ ability to manage communication and coordination, but some respondents disagreed, indicating that understaffing, workload overload, and low system capacity sometimes lead to flight delays.

These results imply the necessity of improved workload management and system upgrades to increase ATC efficiency. Other studies concur, highlighting the use of predictive modeling to optimize controller decisions (Al-Ghzawi and El-Rayes, 2023) and the importance of efficient communication to minimize delay propagation (Li et al., 2021). Furthermore, automation and intelligent systems in ATC operations can enhance coordination and reduce overall flight delays (Zhang et al., 2020).

### The Primary Origin of Flight Delays

Statement	Standard Deviation	Weighted Mean	Remarks
I experience no delays due to taking good weather into heavy consideration when planning future flights.	1.15787	2.43	Agree
I have not experienced delays at one airport that can propagate and impact flights at other connected airports.	0.82874	1.93	Disagree
I have observed that arrival and departure waypoints are carefully managed to maximize airport capacity safely.	0.51887	3.50	Strongly Agree
I have observed the coordination of different personnel (ATC, Ground Handlers, Mechanics) that work together to keep operations safe and efficient.	0.42582	3.79	Strongly Agree
I have observed that ground handling services utilize equipment and work together to prepare the aircraft safely and on time.	0.46881	3.71	Strongly Agree
Total	0.32917	3.07	Agree

Legend: 3.25-4.00 - strongly agree 2.50-3.24 - agree 1.75-2.49 - disagree 1.00-1.74 - strongly disagree

Table 5: Mean and Standard Deviation in Terms of The Primary Origin of Flight Delays

This section presents the statistical findings on the primary origin of flight delays. In the data collection, the table indicates that the standard deviations range from 0.4, the lowest, to 1.15, the highest. The calculated weighted mean from these five statements is 3.124, with respondents mainly selecting “strongly agree.” Based on the collected data, the respondents strongly agreed that they have observed the coordination of different personnel and disagreed that they have not experienced delays at one airport that can propagate and impact flights at other connected airports. This demonstrates the variation in aviation professionals’ viewpoints regarding the causes of the primary origin of flight delays. Due to the complexity of air transportation, the mechanisms of delay propagation at the airport level are not fully understood, and from a macro perspective, airport delays are usually caused by air traffic congestion (Lie et al., 2020). Furthermore, airline hubs located near areas of the network with higher traffic density, independently of the hub’s volume of traffic, are more likely to propagate delays than hubs located in the periphery (Sismanidou et al., 2022).

### Significant Difference in the Respondents View as Professionals between the causality & severity of delays

Statement		Sum of Square	Mean Square	f	Sig.	Decision
I notice that efficient decision-making by air traffic controllers and staff helps reduce uncertainties in arrival, departure, and taxi times.	Between Group	2.214	1.107	12.179	0.002	Reject
	Within Group	1	0.091			
	Total	3.214	1.198			
I often observe that weather conditions and seasonal factors strongly influence whether flights depart or arrive on time.	Between Group	1.607	0.804	11.786	0.002	Reject
	Within Group	0.75	0.068			
	Total	2.357	0.872			
I believe that understanding how delays form and propagate improves our ability to minimize air traffic delays.	Between Group	2.679	1.339	19.643	0	Reject
	Within Group	0.75	0.068			
	Total	3.429	1.407			
I have not experienced delays at one airport that can propagate and impact flights at other connected airports.	Between Group	3.798	1.899	4.071	0.048	Reject
	Within Group	5.131	0.466			
	Total	8.929	2.365			

Legend:

↓ 0. 05 is significant difference/relation - Reject

↓ 0. 01 - very significant

Table 6: Difference in the Respondents' View as Professionals between the causality & severity of delays

Statement	Sig.	Decision
I notice that efficient decision-making by air traffic controllers and staff helps reduce uncertainties in arrival, departure, and taxi times. -*Flight Operation Officer; Ground Crew	0.0010	Reject
I often observe that weather conditions and seasonal factors strongly influence whether flights depart or arrive on time. -*Flight Operation Officer; Aircraft Mechanic	0.0020	Reject
I often observe that weather conditions and seasonal factors strongly influence whether flights depart or arrive on time. -*Ground Crew; Aircraft Mechanic	0.0080	Reject
I believe that understanding how delays form and propagate improves our ability to minimize air traffic delays. -*Flight Operation Officer; Aircraft Mechanic	0.0020	Reject
I believe that understanding how delays form and propagate improves our ability to minimize air traffic delays. -*Ground Crew; Flight Operation Officer	0.0000	Reject
I have not experienced delays at one airport that can propagate and impact flights at other connected airports. -*Flight Operation Officer; Aircraft Mechanic	0.0460	Reject

**Legend:**

↓ 0.05 is significant difference/relation - Reject

↓ 0.01 - very significant

**Table 6: Multiple Comparison of Difference in the Respondents View as Professionals between the causality & severity of delays**

The researchers used ANOVA and Multiple Comparisons to examine the respondents’ perceptions concerning the causality and severity of flight delays, as presented in Table 6. The findings indicated that there were significant differences in all the statements, with p-values ranging from 0.000 to 0.048, thus leading to the rejection of the null hypotheses. This means that professional groups, including Flight Operations Officers, Ground Crew, and Aircraft Mechanics, have different views regarding what mainly causes delays and how severe their effects are. These variations reflect the distinct operational roles and experiences of each group, influencing how they perceive factors such as weather interference, workload distribution, and decision-making effectiveness. Weather, specifically, remains a major determinant of causality for delays, as erratic weather patterns influenced by climate change have been found to increase flight disruptions (Kim & Park, 2024), while inclement weather and ineffective air traffic control coordination tend to exacerbate flight delays, especially during peak-demand periods (Li et al., 2021). In addition, it is noted that improving coordination and decision-making processes in air traffic operations can help address delay propagation (Al-Ghzawi et al., 2023). Human factors and infrastructure limitations also contribute to the escalation of flight delays (Rodriguez-Sanz et al., 2019). Altogether, these findings support the conclusion that both internal operational processes and external factors shape aviation professionals’ perceptions of and control over flight delays in major international airports.

**The Primary Origin of Flight Delays**

Master Theme	Superordinate
Operational Factors that affect flight delays	Aerodrome Limitations
Effects of the ATC in delay period between flights	ATC Efficiency
	Air Traffic Congestion
Primary origins of flight delays	Meteorological Factors
	Facility Constraints

**Table 7: Master Theme based on the informants**

**Master Theme 1.: Operational Factors That Affect Flight Delays Concerning Human, Environmental, and Technical Factors**

**Superordinate 1.1.: Aerodrome Limitations**

Informant 1: “...when weather clears, several operators depart at the same time.”

Informant 2: “...this causes a domino effect leading to ramp congestion.”

Informant 3: “...some airports, like Caticlan, can only accommodate two to three aircraft.”

The limited space, gate access, and runway congestion in major international airports contribute to flight scheduling conflicts and aircraft queuing. Informants experienced frequent ground congestion due to limited taxiways and ramp space, which affects aircraft turnaround time. Informant 3 stated that some airports like

Caticlan Airport can only accommodate two to three aircrafts only and it limits their operations. Informants 1 and 2 also point out that in some cases of delays caused by weather conditions, when the weather clears, aircraft tend to operate at the same time, which causes a domino effect that can lead to ramp congestion. Poor infrastructure limits operational capacity and increases departure delays. Airport expansion and slot coordination are essential to reduce this congestion.

## Master Theme 2.: **Effects of ATC in Delay Period Between Flights**

### Superordinate 2.1.: **ATC Efficiency**

Informant 1: "...our air traffic controllers are well-trained but lack facilities."

Informant 2: "...sometimes, they are understaffed and work beyond their rest periods."

Informant 3: "...fatigue affects decision-making and may contribute to delays."

The effectiveness of air traffic control operations directly affects how quickly flights can arrive, depart, and transition between phases of flight. As Informant 2 stated that sometimes airports are understaffed and some Air traffic controllers work beyond their rest time. This can lead to Fatigue as Informant 3 stated, and affect decision-making and may contribute to delays. Informants stated that modernized ATC systems and proper communication help minimize conflicts and enhance flight flow.

When ATC lacks automation or sufficient manpower, clearance times increase, leading to cumulative flight delays. Air Traffic Flow Management (ATFM), delays to flights. To compensate for anticipated delays and improve on-time performance, Aircraft Operators usually embed a buffer time in their schedules. The current practice for allocating ATFM delays does not take into account whether flights have any remaining schedule buffer to absorb ATFM delay and reduce delay propagation to subsequent flights. (Ivanov et al., 2017).

### Superordinate 2.2.: **Air Traffic Congestions**

Informant 1: "...understanding how delays form helps minimize air traffic disruptions."

Informant 2: "...communication between airports helps manage delays."

Informant 3: "...constant coordination among ATCs, pilots, and ground crews is essential."

Increased air traffic density in major international airport airspace leads to bottlenecks, reducing airspace efficiency and increasing waiting times. But, informants 2 and

3 stated that constant communication and coordination among ATCs, pilots, and ground crew is essential to help airports manage delays. Informants observed congestion during peak hours, causing flight rescheduling and excessive holding patterns. Air traffic congestion occurs when the volume of aircraft exceeds ATC handling capacity, resulting in ground or airborne delays.

Weather events have a significant impact on airport arrival performance and may cause delays in operations and/or constraints in airport capacity. In Europe, almost half of all regulated airport traffic delay is due to adverse weather conditions. Moreover, the closer airports operate to their maximum capacity, the more severe is the impact of a capacity loss due to external events such as weather. (Rodríguez-Sanz et al., 2021). The International Civil Aviation Organization identifies departure and arrival punctuality as key performance indicators. However, these metrics assume a flight's delay is a result of either the origin or destination airport, providing limited information on where delay should be mitigated in the U.S. National Airspace System (NAS). (Atallah et al., 2022)

## Master Theme 3: **The Primary Origins of Flight Delays**

### Superordinate 3.1.: **Meteorological Factors**

Informant 1: "...weather is a big environmental factor that affects flight schedules."

Informant 2: "...delays often occur during the rainy season or poor visibility conditions."

Informant 3: "...phenomena like volcanic eruptions and ashfall can disrupt flight operations."

Weather and seasonal conditions are major contributors to flight delays and cancellations in major international airports. Informant 1 mentioned that the weather is a big environmental factor that affects flight schedules, which can cause flight delays. Informants stated that unpredictable rain and wind conditions delay ground operations and impact departure scheduling. Informant 2 states that delays often occur during the rainy season or poor visibility conditions.

### Superordinate 3.2.: Facility Constraints

Informant 1: "...our air traffic controllers are well-trained but lack facilities."

Informant 2: "...sometimes, they are understaffed and work beyond their rest periods."

Informant 3: "...fatigue affects decision-making and may contribute to delays."

Limited airport facilities and ground handling equipment cause turnaround delays and service bottlenecks. As stated by informant 1 Air traffic Controllers are well-trained but lack facilities that can affect their performance. Informants noted delayed operations due to limited gates, equipment malfunction, and lack of maintenance support.

Facility constraints reduce the airport's ability to manage multiple flights simultaneously, increasing average delay time. Air Traffic Flow Management (ATFM), delays to flights. To compensate for anticipated delays and improve on-time performance, Aircraft Operators usually embed a buffer time in their schedules. The current practice for allocating ATFM delays does not take into account if flights have any remaining schedule buffer to absorb ATFM delay and reduce delay propagation to subsequent flights. (Ivanov et al., 2017).

## DISCUSSION

### Conclusions

Based on the results and analysis, the following were concluded:

1. Results from the informants clarify the factors that contribute to flight delays. The main factor is a cascading effect from small deviations, such as weather conditions that force personnel to delay flights to ensure safety and passenger satisfaction, and aerodrome limitations that hinder operations already affected by delays. Weather factors include rainy seasons with poor visibility and volcanic eruptions or ashfall that can disrupt flights. Delays are also used to ensure aircraft condition and avoid unnecessary maintenance after exposure to extreme weather. Coordination between airports and personnel helps avoid operational limitations caused by high-traffic and the lack of rest periods due to heavy workloads.
2. The findings gathered from the survey and informants reveal that ATCs are highly trained personnel who are certified through a rigorous process. The main problems occur due to the facilities they utilize and control. Delays stem indirectly from their decisions because of inadequate facilities and fatigue. Additionally, understaffed operations and working beyond rest periods affect decision-making. Considering that ATC organizes and regulates airport traffic, it was revealed that innovations in automation and sufficient manpower may help mitigate delays, allowing sudden erratic events to be anticipated before they cause cumulative disruptions.
3. The evaluation of the primary origin of flight delays highlights varying perspectives among aviation professionals. Most aviation professionals strongly agreed that they have observed the coordination of different personnel, the use of ground handling equipment, and careful management of

arrivals and waypoints to maximize airport capacity safely. Aviation professionals held a neutral perspective regarding delays caused by good weather planning, as some agreed that they have not experienced delays at one airport affecting other connected airports, while others disagreed. Environmental factors, such as weather and seasonal conditions, affect flight schedules by reducing visibility, slowing aircraft inspections, and creating safety risks for both passengers and crew. Additionally, limited airport facilities and ground handling equipment contribute to turnaround delays and service bottlenecks, reducing the airport's ability to manage multiple flights simultaneously and increasing average delay times. Overall, while the causes of primary flight delays vary, improving operational efficiency and implementing better technology are necessary to enhance safe flight operations.

4. There is a significant difference in the causality and severity of flight delays, which appear to be distinct under human, environmental, and technical conditions. Weather disturbances, such as inclement weather, heavy rain, and volcanic eruptions, are significant environmental factors that lead to flight delays for safety purposes. Aerodrome constraints, including low runway utilization and ramp congestion, also contribute to delays, particularly during peak operations. Technical and human factors, such as understaffing, fatigue, and outdated air traffic control equipment, further slow decision-making and coordination. Flight delays are therefore the outcome of the cumulative impact of these factors, each contributing differently depending on the situation. This highlights the need for improved coordination, modernized systems, and upgraded infrastructure to minimize incidents at major international airports.
5. The research indicates that flight delays in major international airports are caused by a combination of human, environmental, and technical factors. Informants highlighted that weather has the greatest impact on flight delays. Conditions such as heavy rain, low visibility, and, in rare cases, volcanic eruptions or ashfall, are major contributors that disrupt flight schedules and reduce airport efficiency. Aside from weather, the study also indicates that resource-constrained airport facilities and outdated systems contribute to delays. Overall, the results suggest that flight delays are the result of an interrelated combination of natural factors, infrastructure limitations, and human performance. To address these issues, airports need to upgrade facilities, invest in improved weather monitoring equipment, and enhance coordination among air traffic controllers, pilots, and ground crew. These measures can improve airport operations, reduce delays, and provide safer, more efficient, and more comfortable flight experiences for passengers.

## Recommendations

Based on the discussed conclusions, the recommendations are as follows:

6. The **Passengers** should be informed of the causes of delays, primarily the climatic factors that would hinder their travel experience. This would allow them to take consideration when planning for their flights beforehand, improving their experience through anticipating possible delays, and allowing them to proactively avoid seasons, and allowing them the opportunity to understand the causes of premeditated delays decided upon by **Airport Personnel**. Understanding delays allows our **airport personnel** to prepare procedures beforehand and coordinate with each other to allow a smoother transition into continuing the scheduled operations and enhance the travel experience and safety. This allows **Future Researchers** an opportunity to verify and correct the stated factors for delay with more accuracy and to discern if it is a necessity to promote or impede from occurring on regular airport operations.
7. The **Air Traffic Controllers** should be provided with improved and updated facilities that allow them to carry out proper operations, as well as appropriate rest periods to avoid fatigue that may impede decision-making, thus enhancing their operational efficiency. Utilizing automation and innovation to support their operations would assist in managing high-load operations and allow them ample time to anticipate irregular or erratic operations that, when accumulated, would lead to delay. For the **Ground Crew**, an established communication with the ATC would improve synchronized operations and allow them to prepare the manpower needed for high load operations instead of working at an increased pace while being understaffed. Finally, **Future Researchers** are recommended to conduct further study on innovations that may affect the ATC's ability to operate at a higher efficiency while maintaining appropriate rest, which

allows the production of comprehensive strategies to prevent delay and improve airport operations.

8. For **Ground Crews**, they must ensure that all equipment is working properly and in good working condition before the flight. They must also work more in better coordination to prevent delays. Also, proper training can support them in completing their jobs safely. **Air Traffic Controllers** should maintain clear coordination with pilots and other airport personnel. This will serve to minimize congestion and maintain flights on schedule. Lastly, **Airport Personnel** must enhance airport facilities and services to prevent extended waiting periods and flight delays.
9. For **Passengers**, it is recommended that airports improve the capabilities of communications systems to provide real-time information and comfort facilities for waiting time in the terminals. **Ground Crew** should be supplemented with additional training, improved scheduling practices, and new ground equipment to ease the stress of the workload and improve turnaround time. **Air Traffic Controllers** must be supplemented with new facilities, enough personnel, and sufficient rest periods to make good decisions and mitigate operational fatigue. Airport management will need to invest in new infrastructure development, more taxiways, ramp space, and new air traffic control facilities to reduce congestion and improve capacity. Lastly, **Future Researchers** are encouraged to pursue studying the relationship between environmental variability and human performance at airports, to create long-lasting practices that improve flight on-time performance and service quality.
10. **Passengers** should be informed about the factors contributing to flight delays, particularly environmental conditions such as heavy rain, low visibility, and volcanic activity, allowing them to understand and anticipate possible disruptions that may affect their travel experience. **Ground Crew** is recommended to address operational challenges caused by limited airport resources and outdated systems to improve facilities and communication between personnel to enhance their efficiency and reduce workload stress. **Airport Personnel**, on the other hand is recommended to strengthen coordination with **Air Traffic Controllers** and pilots to ensure quick responses to both technical and environmental issues, minimizing delays and ensuring passenger safety. Lastly, **Future Researchers** may use this study as a foundation for further investigation into how human, technical, and natural factors interact, providing a more comprehensive understanding and helping to develop innovative solutions for smoother and more efficient airport operations.

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