International Journal Of Humanities Education And Social Sciences ***(IJHESS)*** *E-ISSN:* **2808-1765**
Volume 5, Number 4, February 2026, *Page. 1755 – 1761*
Email : editorijhess@gmail.com

Design of an Isolated Parking Area and Its Impact on Air Traffic Services at Soekarno-Hatta International Airport

Slamet Riyanto [1)], Susi Suhardianti [2)], Imam Sonhaji [3)]
[1,2,3)] Air Traffic Management Study Program / Applied Bachelor's Degree, Indonesian Aviation Polytechnic of Curug

*Corresponding Author
Email: Slametriyanto91@rocketmail.com

Abstract

Soekarno-Hatta International Airport is Indonesia's busiest air hub, requiring effective ground traffic management to ensure operational safety and efficiency. One of the critical facilities supporting airport safety is the Isolated Parking Area (IPA), designated for aircraft facing emergencies such as bomb threats, fuel leaks, or hazardous material incidents. This study aims to analyze the design and operational placement of the IPA at Soekarno-Hatta International Airport in relation to air traffic flow and safety services, assessing its compliance with ICAO Annex 14 and Doc 9137 Airport Services Manual standards. Using a qualitative descriptive method with field observations, interviews, and document analysis, the research evaluates the existing location of the IPA on Taxiway WC1. Findings indicate that while the current IPA meets basic safety distance and design requirements, its proximity to main taxi routes creates operational bottlenecks and reduces ground movement efficiency during emergency activation. The study proposes relocation of the IPA to the EC2 area, which offers better spatial separation, direct access routes, and improved safety coordination without disrupting regular aircraft movement. This design adjustment is expected to enhance both airside safety and traffic flow efficiency, aligning with ICAO's "Five Objectives" principles, particularly in maintaining and expediting the flow of air traffic. The research underscores that an optimal IPA design must integrate safety, accessibility, and operational continuity to support the sustainable development of Indonesia's primary international gateway.

Keywords: Isolated Parking Area, air traffic management, airport safety, ICAO Annex 14, Soekarno-Hatta International Airport

INTRODUCTION

Soekarno-Hatta International Airport is one of the largest and busiest airports in Indonesia, serving as the country's primary gateway for both domestic and international flights. With the continuous increase in aircraft movements each year, the airport must provide adequate facilities to ensure the safety and security of passengers, flight crews, and aircraft operations. One of the most essential components in airport operations is aircraft parking management. Improper parking arrangements can lead to accidents, aircraft damage, and even loss of life. Therefore, airports must be equipped with appropriate and well-designed parking facilities that meet established safety and security standards (Direktorat Jenderal Perhubungan Udara, 2025).

Among the various facilities supporting airport safety, the Isolated Parking Area (IPA) plays a vital role. This area is designed to accommodate aircraft that experience emergency conditions, such as bomb threats, fuel leaks, or hazardous material incidents, thereby ensuring that such aircraft are separated from other operational areas. According to the ICAO Doc 9137 Airport Services Manual Part 1, the design of an Isolated Parking Area must consider several aspects: safe distance from terminals, hangars, and fuel installations; appropriate dimensions for the airport's critical aircraft; efficient taxiway access for emergency movement; adequate physical security; and supporting facilities such as drainage and communication systems (International Civil Aviation Organization, 2015).

At Soekarno-Hatta International Airport, the existing Isolated Parking Area is located on Taxiway WC1, between NPW and NP1. This placement complies partially with ICAO standards but presents operational challenges when activated during emergencies. When an aircraft is directed to this area, aircraft departing or arriving must reroute via Taxiway EC1, creating

congestion and disrupting the Five Objectives principle of air traffic services—particularly the third objective: "Expedite and Maintain Flow of Traffic" (SOP Tower JATSC, 2022; International Civil Aviation Organization, 2020). The high traffic density at Soekarno–Hatta, which averages 462 flights per day or more than 69,000 movements in the first five months of 2025, amplifies the potential operational impact of such disruptions (Direktorat Jenderal Perhubungan Udara, 2025).

The ICAO Annex 14 to the Convention on International Civil Aviation: Aerodromes (2020) emphasizes that the Isolated Parking Area must be located at a minimum distance of 100–300 meters from terminals, hangars, and vital facilities, and positioned to minimize interference with the main operational areas. However, the current configuration of the IPA at WC1 does not fully align with these guidelines, as it is situated near the main taxiway system. This raises concerns regarding operational efficiency, emergency accessibility, and safety compliance. Furthermore, based on observations and interviews with Air Traffic Controllers (ATC), Airport Operations Control Center (AOCC) personnel, and Aircraft Rescue and Fire Fighting (ARFF) teams, the existing layout creates additional workload and coordination challenges during emergency situations (Sugiyono, 2013).

Considering these operational complexities, it becomes essential to re-evaluate the design and location of the Isolated Parking Area at Soekarno–Hatta Airport. This study aims to analyze the impact of the current IPA design on air traffic services and to propose an improved layout that aligns with ICAO's international standards. Through qualitative analysis and comparison with regulatory frameworks, this research identifies the need to relocate the Isolated Parking Area to Taxiway EC2, which offers better spatial separation, safer access for emergency vehicles, and less interference with regular aircraft operations. The results of this analysis are expected to provide strategic recommendations for enhancing both safety and efficiency in air traffic flow at Indonesia's main international gateway.

RESEARCH METHODS

This study employs a Research and Development (R&D) approach at Level 1, aiming to produce a conceptual design and assess its operational effectiveness within the airport system. According to Sugiyono (2013), Research and Development is a method used to generate a particular product and to test its effectiveness. Hence, the R&D method in this research focuses on identifying potential and existing problems, designing a conceptual model, and validating the design internally with expert practitioners, without continuing to field testing.

The research procedure follows three key stages as adapted from Aminarno (2019):

1. Preliminary Study, which involves identifying existing problems and potential improvements in the current Isolated Parking Area (IPA) design.
2. Needs Analysis, conducted to determine what type of design is required to address the identified problems.
3. Product Validation, in which the proposed conceptual design is validated by experts and practitioners in the field of airport operations, safety, and air traffic management.

The operational objectives of this research include: (1) identifying the current condition of facilities and procedures at Soekarno–Hatta International Airport through field observation and document analysis, (2) revealing constraints and inhibiting factors affecting the implementation of international standards, and (3) formulating recommendations for improvement to align the facility with ICAO standards while enhancing aviation safety and efficiency.

Population and Sample

The population in this research includes all parties directly or indirectly involved in the planning, operation, and supervision of the Isolated Parking Area at Soekarno–Hatta International

Airport. This comprises management representatives from PT Angkasa Pura II (Persero), operational officers (Apron Movement Control and Airside Operation), Airport Security personnel, Aircraft Rescue and Fire Fighting (ARFF) units, and Air Traffic Controllers (ATC).

Sampling was carried out using the purposive sampling technique, selecting respondents based on specific criteria relevant to the research objectives, such as having at least two years of experience in airport operations, understanding ICAO standards, and having participated in emergency response activities involving the Isolated Parking Area. Based on these criteria, 35 respondents were selected, consisting of 5 airport management staff, 10 airside operational officers, 10 airport security personnel, 5 ARFF members, and 5 air traffic controllers.

Operational Definitions

The independent variable in this study is the Design and Operation of the Isolated Parking Area (IPA), encompassing all aspects of planning, construction, placement, and operational management of the IPA for aircraft carrying hazardous materials, bomb threats, or flammable substances. This variable was measured through indicators such as:

a. Compliance of location with ICAO Annex 14 Volume I (Annex 14 to the Convention on International Civil Aviation: Aerodromes, 2020), particularly regarding safe distance from vital airport facilities, prevailing wind direction, and emergency access routes.
b. Layout and dimensions of the apron relative to the critical aircraft category.
c. Supporting facilities, including grounding points, drainage systems, markings, lighting, and safety equipment.
d. Accessibility for ARFF and security vehicles.
e. Implementation of standard operating procedures (SOP) for landing, parking, handling of hazardous materials, and evacuation.

The dependent variable is Aviation Safety and Security, measured through indicators such as:

a. The level of risk to vital airport facilities arising from incidents in the IPA.
b. Availability of effective evacuation routes and emergency response systems.
c. The degree of operational disruption to other aircraft movements.
d. Compliance with national and international safety regulations.

Data Collection Techniques

To obtain valid and relevant data, this study utilized three primary techniques:

1. Structured and Semi-Structured Interviews, conducted with selected respondents from management, airside operations, airport security, ARFF, and ATC. These interviews explored operational experiences, understanding of SOPs, encountered challenges, and emergency response readiness.
2. Document Analysis, which included reviewing technical layouts, standard operating procedures for handling hazardous aircraft, inspection reports, and official regulations from International Civil Aviation Organization (2015) and national authorities.
3. Field Observation, aimed at examining the physical layout, accessibility, and operational characteristics of the existing Isolated Parking Area (WC1) and the proposed alternative (EC2).

Data Processing and Analysis Techniques

The collected data were analyzed through several stages to produce accurate and comprehensive findings:

1. Gap Analysis, where data from observations, interviews, and documents were compared with international standards (ICAO Annex 14 and ICAO Doc 9137). This process identified discrepancies between the existing conditions of Soekarno-Hatta's IPA and applicable standards, forming the basis for determining improvement priorities.

2. Content Analysis, performed to interpret respondents' qualitative responses and to categorize emerging themes such as operational constraints, safety issues, and accessibility limitations.
3. Comparative Evaluation, conducted by contrasting the characteristics of the current IPA (WC1) and the proposed location (EC2), assessing compliance with technical and operational standards.

The triangulation of sources combining interviews, documentation, and observation ensured data validity and reliability.

Research Schedule and Budget

The research was conducted from June 2025 to March 2026, covering preparation, data collection, data analysis, and report writing stages. The total estimated budget was Rp 4,000,000, allocated for transportation, documentation, administrative fees, and research materials.

This methodology ensures that the study systematically evaluates the design and operational impact of the Isolated Parking Area on air traffic services, aligning with the standards and recommendations established by the International Civil Aviation Organization (2020) and Sugiyono (2013) for applied aviation research.

RESULT AND DISCUSSION

An airport serves as one of the most essential infrastructures within the air transportation system. According to the *Annex 14 to the Convention on International Civil Aviation: Aerodromes (2020)*, an aerodrome is defined as an area of land or water intended for aircraft arrival, departure, and movement, equipped with necessary facilities and installations. This definition emphasizes that an airport encompasses not only runways but also supporting elements such as terminals, aprons, taxiways, navigation systems, and aircraft parking areas. Within this framework, the Isolated Parking Area (IPA) represents a crucial safety facility designed to accommodate aircraft experiencing emergencies, such as fuel leaks, bomb threats, or hazardous cargo incidents, ensuring that such aircraft remain separated from regular operations to prevent greater risks to passengers and infrastructure.

The preliminary findings of this study indicate that the existing Isolated Parking Area at Soekarno-Hatta International Airport is located at Taxiway WC1, positioned between NPW and NP1 on the western side of Runway 07R. While this placement meets several safety standards, it presents operational challenges, particularly during emergency activation. When the IPA is in use, aircraft arrivals and departures must be rerouted through Taxiway EC1, resulting in congestion and delays in airside operations. This condition contradicts the *Five Objectives* of air traffic services outlined by the *International Civil Aviation Organization (2020)*, specifically the principle of "expedite and maintain flow of traffic." Furthermore, data from the *Directorate General of Civil Aviation (2025)* indicates that Soekarno-Hatta handles an average of 462 flights per day, or approximately 69,000 movements in the first five months of 2025, highlighting the scale of air traffic that intensifies operational demands and coordination complexities.

A comparison between the current condition and the standards set forth in *ICAO Annex 14 Volume I* and *ICAO Doc 9137 Airport Services Manual* (International Civil Aviation Organization, 2015; 2020) reveals several key discrepancies. The location at WC1 complies with the minimum safety distance requirement of 100–300 meters from terminals and hangars but fails to fulfill the operational efficiency standard, as its proximity to the main taxiway causes bottlenecks in ground movement. Interviews conducted with air traffic controllers and airside operations personnel confirm that each activation of the IPA at WC1 significantly disrupts ground flow and increases controller workload, indicating that safety and efficiency have not been optimally balanced within the current design.

From a locational perspective, the WC1 area provides basic compliance with ICAO's spatial criteria, yet its closeness to active taxiways heightens the risk of interference with routine operations. In contrast, the proposed alternative at EC2 offers greater spatial separation and improved safety. The EC2 location allows emergency aircraft to be parked in isolation without affecting the primary maneuvering area, thereby supporting uninterrupted traffic flow. Accessibility is another critical factor in the evaluation. The current WC1 route requires complex taxiway coordination, making it difficult for emergency vehicles to respond promptly. The proposed EC2 site, however, provides a more direct and dedicated taxiway, reducing ATC coordination complexity and enabling faster emergency access as emphasized in *ICAO Doc 9137* (International Civil Aviation Organization, 2015).

In terms of dimensions and clearance, the WC1 site can accommodate large aircraft but has limited space for the movement of emergency vehicles. The EC2 site offers a broader apron and a larger buffer zone, which facilitates safer operations for the Aircraft Rescue and Fire Fighting (ARFF) team during emergencies. Security and surveillance were also found to be stronger at EC2, as its more isolated location allows for better monitoring with fewer operational distractions. While WC1 meets basic ICAO requirements for fencing, lighting, and restricted access (*Annex 14 to the Convention on International Civil Aviation: Aerodromes, 2020*), EC2 provides enhanced visibility and allows for continuous monitoring using CCTV and patrols.

Another key aspect of the assessment concerns communication and supporting facilities. The existing WC1 area is adequately connected to communication systems but is situated farther from the Airport Operations Control Center (AOCC), leading to slower coordination during emergency events. EC2, located closer to the AOCC, enables faster response and communication between operational teams. Moreover, EC2 has more favorable topography and drainage systems, allowing it to handle fuel spills or hazardous materials more effectively, as prescribed by *ICAO Doc 9137* (International Civil Aviation Organization, 2015).

Field interviews and observations identified several operational challenges. First, congestion is a major issue when the IPA at WC1 is active, forcing rerouting and causing delays in ground operations. Second, coordination complexity increases, as controllers must issue multiple instructions to redirect aircraft, thereby raising their cognitive workload (*Sugiyono, 2013*). Third, response delays were reported by ARFF teams, who required four to seven minutes longer to access WC1 compared to EC2. Lastly, these operational inefficiencies result in non-compliance with ICAO's principle of maintaining smooth and efficient traffic flow (*International Civil Aviation Organization, 2020*).

Overall, the analysis reveals that partial compliance with ICAO design standards does not necessarily ensure operational effectiveness. The current location of the IPA at WC1 satisfies several structural requirements but fails to support seamless air traffic flow. This finding reinforces the notion that safety infrastructure should not only be evaluated based on technical conformity but also on its systemic impact on airport operations. The proposed relocation of the IPA to EC2 offers both geographic and operational advantages, providing better separation for emergency aircraft while maintaining smooth regular operations. This configuration enhances system resilience, allowing the airport to continue functioning effectively under abnormal or emergency conditions.

The integration of human, technical, and procedural factors in the proposed EC2 design supports a more proactive safety management approach. It simplifies coordination among Air Traffic Control (ATC), ARFF, AOCC, and airport security teams, aligning with the preventive and predictive philosophy of modern *Safety Management Systems (SMS)* promoted by ICAO. The EC2 proposal is thus not only compliant with international regulations but also operationally efficient, offering a model that strengthens the airport's safety framework without sacrificing performance. In summary, the relocation of the Isolated Parking Area from WC1 to EC2 represents a strategic enhancement that improves both safety and operational efficiency at

Soekarno–Hatta International Airport, ensuring that the facility meets global aviation standards while optimizing the flow of air traffic management.

CONCLUSION

This study concludes that the existing Isolated Parking Area (IPA) at Taxiway WC1 in Soekarno–Hatta International Airport only partially meets the technical and operational standards set by *ICAO Annex 14* and *ICAO Doc 9137*. Although the location satisfies minimum safety distance requirements, it causes interference with normal aircraft movements and increases the workload for Air Traffic Controllers (ATC). The current placement also makes it difficult for emergency vehicles, such as Aircraft Rescue and Fire Fighting (ARFF) units, to reach the area quickly, leading to potential delays during emergency handling.

The analysis shows that the WC1 location does not fully support the *Five Objectives* of air traffic management, particularly the goal to "expedite and maintain flow of traffic." The proximity of WC1 to busy taxiways creates congestion and operational inefficiencies, which reduce the overall performance of airport ground operations.

Relocating the IPA to the EC2 area is considered a more effective solution. The EC2 site provides better isolation, wider clearance, easier access for emergency response, and improved coordination with the Airport Operations Control Center (AOCC). This alternative design ensures that emergency aircraft can be handled safely without disrupting normal traffic flow.

Overall, moving the Isolated Parking Area to EC2 aligns better with ICAO standards and enhances both safety and efficiency at Soekarno–Hatta International Airport. The proposed relocation strengthens the airport's ability to manage emergencies while maintaining smooth, continuous air traffic operations.

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