ANALYSIS OF THE COMPLEXITY OF THE SECURITY SYSTEM AT HANG NADIM INTERNATIONAL AIRPORT IN BATAM IN MANAGING THREATS FROM DANGEROUS GOODS USING A THEORETICAL AND EMPIRICAL APPROACH

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ABSTRACT

Airport security systems play an important role in preventing potential threats, particularly those involving dangerous goods that could compromise flight safety. Hang Nadim Batam International Airport is one of the national vital objects facing challenges in managing dangerous goods carried intentionally or unintentionally by passengers. This study aims to analyze the complexity of the security system in managing these threats using relevant theoretical and empirical approaches.

The study examines national policies, particularly Minister of Transportation Decision No. KM 39 of 2024, as a reference for managing dangerous goods in the airport environment. The empirical approach was conducted through direct observation, interviews with security personnel, and analysis of field findings related to hazardous materials at various checkpoints such as PSCP, HBSCP, and cargo areas. This study uses a theoretical and empirical approach as the analytical framework.

The results of the study indicate that the security system at Hang Nadim Airport is complex and adaptive. This is reflected in the high number of hazardous materials found and the mitigation procedures implemented. The system is in line with the provisions of KM 39 of 2024, although there are still challenges in terms of technical aspects and human resources. These findings confirm the hypothesis that the security system implemented is comprehensive and responsive to the dynamics of threats.

Keywords: Airport security, Dangerous Goods, Complex system, Hang Nadim, KM 39 of 2024

1. INTRODUCTION

An airport is an infrastructure that functions as a center for air transportation services. According to Law of the Republic of Indonesia Number 1 of 2009 Article 1 paragraph 33, an airport is defined as an area on land and/or water with certain boundaries that is used for aircraft landing and takeoff, passenger boarding and disembarking, and cargo loading and unloading activities. Additionally, an airport serves as a transportation hub, both within the transportation system itself and between modes of transportation, equipped with safety facilities, aviation security measures, and other primary and supporting facilities (Ministry of Transportation of the Republic of Indonesia, 2009)

Hang Nadim Batam International Airport is one of the business entities owned by the Batam Development Authority (BP Batam). Located approximately 22 kilometers from the center of Batam City in the Riau Islands Province, this airport occupies a strategic position in the golden triangle trade corridor connecting Indonesia, Malaysia, and Singapore. According to data from BP Batam in 2025, Hang Nadim International Airport in Batam covers an area of 1,762 hectares and has a terminal spanning 30,000 square meters. Its runway stretches 4,025 meters in length and 45 meters in width, making it the longest in Indonesia and the second longest in Southeast Asia.

Airport security is a critical aspect of aviation operations to ensure the safety of passengers, crew, and airport facilities from various threats posed by hazardous materials. The complexity of the security system at Hang Nadim Batam Airport stems from the need to detect and handle various types of prohibited items (PI), which, according to Anjelintina (2024), include hazardous materials such as flammable substances (Dangerous Goods), devices that can be used as weapons (Dangerous Devices), and weapons themselves.

According to data from the International Civil Aviation Organization (ICAO) in 2024, incidents related to aviation security threats, such as attempts to smuggle weapons, the discovery of items considered dangerous, and explosives, continue to rise alongside evolving criminal tactics, such as the 2024 case at Djuanda International Airport involving the smuggling of a pistol along with six 9mm bullets, where the bullets from the pistol were placed inside a black bag and wrapped in bubble wrap, and the firearm was factory-made rather than homemade. This indicates that airport security systems must be able to adapt to increasingly complex challenges.

With the high volume of aviation and logistics activities at Hang Nadim Batam Airport, the risk to aviation security has increased, particularly regarding the discovery of hazardous materials carried by passengers and within cargo shipments. This not only has the potential to disrupt airport operations but also impacts the security of Hang Nadim Batam International Airport. In recent months, specifically from November 2024 to January 2025, nearly every day saw several cases where passengers were found carrying various types of hazardous materials.

Based on data on prohibited items (PI) found at Hang Nadim Batam International Airport during the period from November 2024 to January 2025, it is evident that the challenges in maintaining airport security are complex and encompass various aspects. This is evident from the diverse types of hazardous items that were successfully seized, ranging from flammable materials and oxidizing agents (Dangerous Goods), potentially harmful tools such as scissors, razors, and screwdrivers (Dangerous Devices), to weapons. These items were found at various checkpoints, such as HBSCP, PSCP, and CARGO, each monitored by different security teams: Alpha, Bravo, Charlie, and Delta.

In November 2024, 807 items were secured, consisting of 273 items classified as Dangerous Goods and 534 Dangerous Devices. This number rose sharply in December 2024 to 1,058 items, and increased again in January 2025 to 1,102 items. In the last month, 20 items from a new category, Explosives, were also found, which had not been identified previously. This increase indicates that the security system not only maintains consistency in detection but also demonstrates the ability to adapt to evolving threats.

These findings were spread across three main zones: Passenger Security Check Point (PSCP), Hold Baggage Screening Check Point (HBSCP), and the cargo area. This distribution pattern confirms the implementation of a defense-in-depth strategy, where each surveillance point has a specific security approach. PSCP focuses on passenger carry-on items, HBSCP on checked baggage, while cargo surveillance requires comprehensive procedures due to its high volume and complexity.

However, Hang Nadim Batam International Airport has already implemented various regulations related to airport security, including the Minister of Transportation's Decision No. 39 of 2023 on National Aviation Security. However, the effectiveness of the implementation of these policies at Hang Nadim International Airport in Batam still needs to be evaluated systematically. Therefore, it is important to study the complexity of the airport security system in managing hazardous materials threats to ensure that the existing system can operate optimally and adapt to evolving threats.

The approach used in this study includes a theoretical analysis of global aviation security policies implemented at Hang Nadim International Airport in Batam, as well as an empirical approach involving direct observation, interviews with airport security officers, and analysis of the implementation of security technology. The security system at the Security Check Point at Minangkabau International Airport shows that a structured and technology-based approach is a key element in security management (Dian Novita, 2020). Therefore, with this combination of methods, this study is expected to provide deeper insights and applicable solutions for improving airport security systems.

From a practical perspective, this study is expected to evaluate the effectiveness of the security system at Hang Nadim Batam International Airport in detecting and preventing threats from hazardous materials. Additionally, this study offers recommendations for airport managers and national aviation authorities to improve security systems based on empirical data, emphasizing the urgency of strict oversight in the transportation of dangerous goods at airports (Amirudin & Widagdo, 2023).

With the increasing threats to aviation security, particularly those related to dangerous goods, it is important to analyze the complexity of the airport security system comprehensively. This study combines theoretical and empirical approaches to evaluate the effectiveness of the security system implemented at Hang Nadim International Airport in Batam and provides data-based recommendations that can enhance overall airport security. Therefore, this research is presented in a final project titled “ANALYSIS OF THE COMPLEXITY OF THE SECURITY SYSTEM AT HANG NADIM INTERNATIONAL AIRPORT IN BATAM IN MANAGING HAZARDOUS MATERIAL THREATS USING A THEORETICAL AND EMPIRICAL APPROACH.”

2. METHOD

2.1 Research Method

In this study, researchers used a qualitative approach with a case study design. A case study is a form of research that involves an in-depth examination of individuals, groups, organizations, programs, or specific activities over a specific period of time. In line with the qualitative research approach, data in case studies are typically collected through interviews, observations, and relevant documents or archives (Dr. H. Zuchri Abdussamad, S.I.K., 2021).

2.2 Research Design

Research design is a series of steps and techniques applied to collect and analyze data in order to identify the variables that are the focus of the study. In its implementation, there are several stages that need to be carried out. The researcher adopted a qualitative research design according to Sugiyono (2010). This research began with the "Start" stage, which is the initial phase for determining the direction of the research. At this stage, the researcher identifies the main problem that forms the basis of the research, namely the increasing threat to aviation security due to the discovery of various types of dangerous goods at Hang Nadim International Airport in Batam. The researcher then formulates the research question, objectives, limitations, and hypotheses that serve as the initial foundation for this research.

The next stage is "Observation," where the researcher directly observes the implementation of security tasks by airport security (AVSEC) personnel in the field (Musadek et al., 2022). Observation is often used as a data collection technique in research aimed at examining behavior. This observation was conducted during the On-the-Job Training (OJT) period from January to February 2025. The focus of the observation was on the implementation of security systems at various checkpoints such as the Passenger Screening Check Point (PSCP), Hold Baggage Screening Check Point (HBSCP), and cargo areas. The objective was to collect factual data on security practices and identify any complexities in the implemented system.

After the observation was conducted, the researchers proceeded to the "Literature Study" stage. In this section, the researchers explored various theoretical references and previous research results related to aviation security, hazardous material detection systems, and theoretical and empirical approaches. A literature study is a method of data collection by gathering documents, including written documents, images, and electronic documents, literature, reference materials, browsing, and theoretical studies. This study aims to build a strong conceptual foundation for analyzing field findings. The literature sources used include legislation, scientific journals, and academic documents relevant to airport security systems.

The next stage is "Instrument Development," which includes the design of research tools such as interview guides for AVSEC Team Leaders, observation forms, and documentation formats. The purpose of this stage is to ensure that the data collection process is structured, measurable, and capable of recording accurate information. The instruments are developed based on the results of literature studies and initial field observations.

Next, the researchers enter the "Data Collection" phase, which is the core of the empirical approach. In this phase, the researcher combined several methods, including in-depth interviews with six AVSEC Team Leaders, photographic documentation of hazardous items found, and field observations. Triangulation techniques were used to verify the validity of data from various sources, ensuring that the results obtained were more objective and reliable. The data collected reflects the real dynamics and challenges in the implementation of security systems at airports.

After all the data is collected, the researcher proceeds to the "Report Preparation" stage. In this stage, the researcher processes, analyzes, and organizes the data into a systematic narrative. The resulting report includes an introduction, theoretical framework, research methodology, analysis results, discussion, and conclusions and recommendations. The analysis is conducted using descriptive qualitative methods to uncover the complexity of airport security systems based on field findings and relevant theories. The final stage in this research process is "Completion," indicating that the entire research process has been carried out comprehensively and systematically.

2.3 Research Subject

2.3.1. Population

Population refers to the entire collection of objects or individuals that have certain characteristics and are the focus of a study, with the aim of analyzing them and drawing conclusions from them (Hardani et al., 2023). In this study, the researchers determined that the total number of airport security (AVSEC) personnel, namely 210 personnel, who work at Hang Nadim International Airport in Batam, constitute the population to be studied.

2.3.2. Sample

In this study, the researcher used purposive sampling. Sugiyono (2019) explains that purposive sampling is a method of selective sample selection in qualitative research that aims to explore the richest and most meaningful information by involving individuals who are considered to have a deep understanding of the phenomenon being studied because of their roles, experiences, or special insights.

The selection of samples was carried out by considering the role of informants in maintaining security at Hang Nadim International Airport in Batam, particularly in terms of the management and handling of hazardous materials and related regulations from the airport authority, which only allows data collection by airport security personnel holding the position of AVSEC unit team leader. Therefore, the researcher identified six AVSEC Team Leaders as primary informants, given their positions and expertise in understanding standard operating procedures, changes in threat situations, and the performance of security systems directly in the field.

2.4 Data Collection Techniques

In this study, data collection was conducted through multiple sources and methods to ensure the comprehensiveness and accuracy of the findings. Based on its origin, data can be classified as either primary, which is collected directly from informants, or secondary, which is obtained indirectly through intermediaries such as documents or archival records (Hardani et al., 2023). The researcher employed a combination of four key techniques: observation, interviews, documentation, and literature review.

Observation was conducted during the researcher's On the Job Training (OJT) period at Hang Nadim International Airport, from January 6 to February 28, 2025. This involved systematic and continuous monitoring of AVSEC personnel behavior and security procedures in their natural operational setting to capture real-time dynamics and complexity in the handling of dangerous goods (Sugiyono, 2019). To complement this, in-depth interviews were carried out with selected AVSEC Team Leaders. These sessions served to enrich the empirical data with insights from experienced personnel who are directly involved in the management and enforcement of airport security. Interviews were especially useful in identifying operational challenges and validating the findings from observations (Sugiyono, 2019).

In addition to verbal data, documentation was also employed to collect visual and textual evidence in the form of photographs and official records of dangerous goods found at the PSCP, HBSCP, and cargo inspection areas. These materials, gathered during the OJT, provided contextual support and served as additional verification tools (Zuchri Abdussamad, 2021).

To enhance data validity and ensure triangulated reliability, the researcher implemented triangulation techniques, which involve cross-verifying data from multiple methods—namely observation, interviews, and documentation—against the same unit of analysis (Sugiyono, 2010). This methodological triangulation aims to reduce bias and improve the integrity of the research by offering a more comprehensive and multidimensional understanding of the airport's security system in managing threats posed by dangerous goods.

2.5 Data Analysis Technique

The process of data analysis in this study follows the interactive model introduced by Miles and Huberman, which consists of three key steps: data reduction, data display, and conclusion drawing with verification. These steps were conducted iteratively alongside the data collection process to ensure that analysis was both continuous and reflective.

The first stage is data reduction, which began simultaneously with data collection. In this phase, the researcher filtered, selected, and simplified raw data gathered from interviews, observations, and documents into more focused and meaningful information. This step was not merely about discarding irrelevant data but rather about sharpening the analytic focus to align with the research questions. By categorizing and coding key information, the researcher was able to manage the volume and complexity of the collected data effectively.

The second stage is data display, where the reduced data were organized and structured in a way that enabled pattern recognition and identification of relationships or emerging trends. Data were presented using descriptive narratives, tables, and matrices to make the findings more interpretable and to facilitate analytical reflection. This visual and narrative arrangement of information helped the researcher connect fragmented data points and derive insights.

Finally, the third stage involves drawing conclusions and verifying findings. At this point, the researcher interpreted the processed data to answer the research objectives, identifying recurring patterns, relationships between variables, and potential propositions. Importantly, these conclusions were continuously verified through comparison across sources and methods—ensuring that they were valid, reliable, and grounded in empirical evidence.

2.6 Research Instrument

Sugiyono (Sugiyono, 2019) argues that in qualitative research, the main instrument is the individual or human instrument, namely the researcher himself. In order to act as a research instrument, researchers need to have a deep theoretical understanding and broad insight. This enables the researcher to ask questions, analyze data, describe the observed social conditions, and formulate clearer and more meaningful interpretations. Therefore, the researcher uses structured interviews as the research instrument in this study.

QUESTION	SUBJECT
What are the standard procedures implemented by AVSEC in detecting and handling dangerous goods at Hang Nadim Airport?	*Team Leader of AIRPORT SECURITY (AVSEC) personnel at Hang Nadim International Airport, Batam*
What are the biggest challenges faced by AVSEC in managing airport security, particularly in relation to dangerous goods?	
How effective is the current dangerous goods detection system, both manually and technologically?	
How does AVSEC coordinate with other parties (e.g., Customs,	

QUESTION	SUBJECT
Police, or airlines) in handling dangerous goods threats?	
Are there differences in handling hazardous materials found in passenger luggage and cargo?	
How frequently do AVSEC personnel receive training related to identifying and handling hazardous materials?	
Are there regular simulations or tests to assess personnel readiness in addressing hazardous material threats?	
How does AVSEC manage the pressure or stress faced in their high-risk daily work?	
What technologies are used to detect dangerous goods at Hang Nadim Airport?	
How accurate are X-ray scanners in detecting dangerous objects, and how are suspicious results handled?	
How often are security systems and scanning technologies updated to keep pace with evolving threats?	
Does AVSEC have special procedures for handling dangerous goods that are not detected by scanning equipment?	
Are national and international aviation security regulations sufficient to support AVSEC in handling dangerous goods?	
Are there any challenges in implementing regulations related to aviation security, and how does AVSEC address them?	
What actions are taken if there are violations of regulations related to dangerous goods?	

3. RESULT AND DISCUSSION

The research conducted at Hang Nadim International Airport between January and March 2025 reveals key findings regarding the complexity of its aviation security system, especially in handling threats from dangerous goods. Using a combination of direct observation, in-depth interviews with six AVSEC team leaders, and document analysis, this study offers both theoretical and empirical insights into airport security operations.

3.1 Complexity of the Security System: A Theoretical Approach

From a theoretical standpoint, the complexity of Hang Nadim Airport's security system arises from the interaction between regulatory frameworks, technological infrastructure, and human resources. This aligns with the definition of complexity in systems theory, which views a system as a dynamic structure influenced by both internal and external interactions (Rahayu & Mardiana, 2016; Heryana & Unggul, 2021). Hang Nadim Airport has implemented multi-layered security systems based on national regulations—such as the Minister of Transportation Regulation No. KM 39 of 2024 on National Aviation Security—which emphasize risk-based security management and cross-agency coordination (Menteri Perhubungan Republik Indonesia, 2024).

The AVSEC unit operates under a tiered organizational structure that includes divisions for passenger screening (PSCP), hold baggage screening (HBSCP), and cargo inspection. Each of these functions is supported by technological tools such as dual-view X-ray machines, Explosive Trace Detectors (ETD), and Walk-Through Metal Detectors (WTMD), which are integrated into security standard operating procedures (Menteri Perhubungan, 2022; Sylvia Kuhne, 2024).

3.2 Complexity of the Security System: An Empirical Approach

Empirical findings further validate the system's complexity. During the three-month research period, there was a steady increase in the number of dangerous items discovered. In November 2024, 807 prohibited items were confiscated; this figure rose to 1,058 in December and peaked at 1,116 items in January 2025. These items included Dangerous Goods, Dangerous Devices, and—uniquely in January—Explosives, marking a significant escalation in threat type and sophistication.

These items were intercepted across all three strategic zones—PSCP, HBSCP, and cargo—reflecting the airport's layered "defense-in-depth" approach (Musadek et al., 2022). Each zone is monitored by designated AVSEC squads (Alpha, Bravo, Charlie, Delta), which

handle different stages of inspection. Observations confirm that detection tools such as X-ray machines and ETDs achieved accuracy rates between 90% and 99%, although manual verification remained indispensable, especially for ambiguous or high-risk items.

Interviews with AVSEC Team Leaders revealed additional operational challenges. One recurring issue was passenger resistance to security regulations, especially regarding the confiscation of seemingly harmless items such as scissors or lighters. Another issue was coordination fatigue, where multiple agencies—including Customs, Police, and airlines—had to work together, often under stressful conditions and misaligned protocols (Amirudin & Widagdo, 2023).

Furthermore, personnel welfare emerged as a concern. High mental workloads, repetitive shift patterns, and pressure during peak traffic seasons (such as the 2024/2025 holiday period) contributed to stress and reduced alertness. Despite the availability of technological tools, personnel effectiveness is still highly dependent on continuous training, motivation, and institutional support.

4. CONCLUSION

The findings of this study, conducted at Hang Nadim International Airport in Batam between January and March 2025 through a combination of direct observation, in-depth interviews, and documentation analysis, reveal that the airport's security system operates within a highly complex environment shaped by the interplay of regulatory frameworks, technological infrastructure, and human resource capabilities. The multilayered security architecture integrates advanced detection tools—including dual-view X-ray scanners and Explosive Trace Detectors (ETD)—with both national and international aviation security standards. This integration is essential in addressing a growing spectrum of threats, particularly the smuggling of hazardous materials such as dangerous goods, explosives, and radioactive substances. These evolving challenges demand a security system that is not only compliant with standard operating procedures (SOPs) but also adaptive and responsive.

Field observations and interviews further highlight several operational challenges. These include passenger resistance to regulatory enforcement, a significant rise in the volume of dangerous goods intercepted—reaching a peak of 1,126 prohibited items in March 2025—and the predominance of dangerous devices among those items. While detection equipment has demonstrated an accuracy rate of approximately 90–99%, manual inspections and secondary verification continue to play a critical role in the overall screening process. Moreover, coordination with external agencies such as Customs, Police, and airlines adds further complexity to security operations, requiring clear communication and synchronized procedures.

To enhance the overall effectiveness of the airport's security system, several strategic measures are recommended. First, detection technologies must be optimized through regular updates, recalibration, and reconfiguration to address emerging threat patterns. Second, the competencies of AVSEC personnel should be continuously developed through intensive training programs, simulation exercises, and periodic performance evaluations. Third, inter-agency coordination must be institutionalized through structured forums and joint operational planning to ensure procedural alignment and facilitate swift, integrated responses to threats. Fourth, passenger education should be improved via targeted digital and physical outreach within airport premises to foster awareness and compliance with security protocols. Additionally, the well-being of security personnel must be prioritized through stress management initiatives, including work rotation systems, psychological counseling, and mental health support. Lastly, a robust system of internal audits and routine evaluations must be established to ensure continuous improvement and the long-term sustainability of a dynamic and resilient airport security system.

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