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Development of a Total War Strategy to Face Cyber Threats in Aviation Systems: A Case Study of Asean Regional Strategic Environment and its Implications for Aviation Security

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ABSTRACT
The background of this research is driven by the increasing frequency and complexity of cyberattacks targeting global and regional aviation systems, which threaten aviation safety and national sovereignty. This research aims to analyze the implementation of aviation security measures in addressing cyber threats and to formulate the most effective strategies for strengthening national digital defense from the perspective of the Universal War Strategy. This study employs a qualitative descriptive method, grounded in two main theoretical foundations: George C. Edward III's policy implementation theory and Carl von Clausewitz's military strategy theory, which are operationalized through SWOT-AHP analysis. The results of the study indicate that the implementation of cybersecurity policies in Indonesia's aviation sector continues to face challenges related to communication, resources, executive disposition, and bureaucratic structure. Empirically, only 37% of national airport operators have established Cyber Incident Response Teams (CSIRTs), while the allocation of digital security budgets remains below the ICAO recommendation of 2% of the total operational budget. Based on the SWOT-AHP analysis, the highest priority strategy involves integrating national cybersecurity with aviation systems (weight 0.36), followed by enhancing human resource capacity and strengthening regional cyber intelligence cooperation. This research contributes significantly to the expansion of the paradigm, extending the concept of universal warfare into the digital domain as a strategic instrument to safeguard national aviation security and sovereignty in the cyber era.

INTRODUCTION

The development of global digital technology has brought significant changes to all aspects of human life, including the aviation sector. Modern aviation systems—including aircraft, navigation systems, air traffic management (ATM), and airport infrastructure—are increasingly reliant on integrated information and communication technology (Ansell, 2023; Blundell & Harris, 2023; Sun et al., 2021; ZIO et al., 2019). This digital transformation enhances operational efficiency but, at the same time, increases vulnerability to cyber threats that have the potential to disrupt aviation safety and security (International Civil Aviation Organization [ICAO], 2019).

In the context of the global strategic environment, cyber threats to aviation have risen significantly in the past decade. Incidents such as the hacking of major airline data, including easyJet (2020), and attacks on global aviation information technology system provider SITA (2021)—which led to the data leak of more than four million passengers—demonstrate that this threat is no longer hypothetical but factual, with broad strategic impacts (The Guardian, 2020; The Guardian, 2021). Cyberattacks not only affect the economic dimension but also undermine

safety and security, which form the core of the international aviation system (Ukwandu et al., 2022).

ICAO (2019), in its Aviation Cybersecurity Strategy, emphasizes that cyber threats to aviation are a global issue that must be addressed through a multi-level, collaborative, and resilience-by-design-oriented approach. This requires integrating cybersecurity throughout the entire aviation system lifecycle—from design and operation to maintenance. The strategy also highlights the importance of international cooperation and information exchange mechanisms among countries to minimize cross-border risks (Marin, 2020).

Within the ASEAN regional strategic environment, the development of cybersecurity is a key issue as the region's connectivity and economic integration grow. ASEAN established the ASEAN Cybersecurity Cooperation Strategy (2021), which underscores the importance of regional collaboration in enhancing the ability to detect, prevent, and respond to cyber threats targeting critical infrastructure, including the aviation sector (ASEAN Secretariat, 2021). However, capacity and readiness levels among ASEAN countries still vary—in regulations, technological infrastructure, and human resources (ASEAN Secretariat, 2021). This condition creates a security gap that can be exploited by cross-border cyber actors, whether individuals, organized criminal groups, or state-sponsored entities.

The ASEAN Cyber Threat Assessment 2023 report reveals that attacks on transportation and digital infrastructure sectors increased by 35% compared to the previous year, with most incidents involving phishing, ransomware, and cloud-based system exploitation (ASEAN Secretariat, 2023). These data show that Southeast Asia has become a strategic target in the evolving landscape of global cyber threats.

At the national level, Indonesia has reaffirmed its commitment to cybersecurity through the establishment of the State Cyber and Cryptography Agency (BSSN) under Presidential Regulation No. 28 of 2021 (BSSN, 2021). This institution is tasked with building national cyber resilience, including in the transportation and aviation sectors. Furthermore, the Ministry of Transportation of the Republic of Indonesia has issued aviation safety regulations that incorporate digital information security through the Civil Aviation Safety Regulations (CASR). However, a gap remains between national policy and technical field implementation, particularly regarding the integration of cybersecurity into aviation safety systems (Ministry of Transportation of the Republic of Indonesia, 2022).

From the perspective of security theorists and experts, traditional security approaches that rely solely on physical and technical measures are inadequate for addressing modern cyber threats. The concepts of resilience-by-design and defense-in-depth must be adopted to ensure aviation systems can withstand and recover quickly after cyberattacks (ICAO, 2019). Defense strategists emphasize that cybersecurity represents a new domain of multidimensional warfare. Therefore, integration among military, civilian, industrial, and academic sectors is essential—an approach that, in the Indonesian context, is known as the universal war strategy (Sumarto, 2020).

The concept of Total War Strategy is a national defense strategy emphasizing the participation of all national components—both military and non-military—to safeguard sovereignty and security (TNI, 2018). Regarding cyber threats to aviation systems, a universal war strategy entails concerted efforts among governments, flight operators, airport authorities, the technology industry, and the digital society to build a multilayered and sustainable cybersecurity system. This approach aligns with the vision of national cyber defense that positions cyberspace as a strategic domain of national defense (BSSN, 2021).

Factual threats underscore the urgency of such a strategy. The Aviation Cyber Threats 2023 report by Resilinc recorded a 43% increase in cyber incidents in the global aviation sector over the past three years, including attacks on airport navigation, radar, and communication systems (Resilinc, 2023). These attacks not only cause billions of dollars in financial losses but

also endanger civil aviation safety. Other potential threats include GPS spoofing, sabotage of Automatic Dependent Surveillance–Broadcast (ADS-B) systems, and infiltration of commercial aircraft Flight Management Systems (FMS) (IATA, 2024).

The ideal condition, according to ICAO (2019) and IATA (2024), involves forming a cyber-resilient aviation ecosystem through multi-level governance policies, international collaboration, capacity building, and harmonized standards and certifications. In the ASEAN context, aviation cybersecurity strategies must also support cross-border cooperation, cyber intelligence sharing, and joint exercises among member states (ASEAN Secretariat, 2023).

From both academic and policy perspectives, research on the development of a universal war strategy for addressing cyber threats to aviation systems in the ASEAN region is highly relevant. This approach highlights not only technical aspects but also the social, legal, diplomatic, and military dimensions in a comprehensive and collaborative manner. Such studies can contribute to strengthening national cyber defense and fostering the establishment of a resilient and adaptive regional aviation security system (Berkol & Demirtaş, 2024).

Despite increased recognition of aviation cybersecurity risks, most existing research focuses primarily on technical resilience measures—such as firewall implementation, intrusion detection systems, and network segmentation protocols. While valuable, this technical emphasis neglects the strategic policy dimensions essential for a comprehensive national defense. This research addresses that gap by integrating Clausewitz's Total War framework into aviation cyber defense policy analysis, bridging military strategic theory with modern digital security challenges.

The novelty of this study lies in applying Clausewitz's Ends-Ways-Means strategic model to the digital warfare context, specifically adapting universal war theory to aviation cybersecurity policy implementation. This theoretical integration supports a holistic approach that highlights not only technical dimensions but also social, legal, diplomatic, and military aspects within comprehensive and collaborative frameworks.

This research has three primary objectives: first, to evaluate the current implementation of aviation security in confronting cyber threats using Edward III's policy implementation framework; second, to formulate optimal strategies for addressing aviation cyber threats through SWOT–AHP analysis grounded in Clausewitzian strategic theory; and third, to propose an integrated Digital Universe War model that synthesizes civilian, military, and technological forces for national cyber defense. This study enriches academic discourse by expanding universal warfare paradigms into digital domains and informs policy practice by offering evidence-based strategic recommendations. Its implications include strengthening Indonesia's national cyber resilience and fostering a more robust ASEAN regional aviation security architecture capable of adapting to evolving cyber threats.

RESEARCH METHOD

This research employed a qualitative descriptive method as articulated by Creswell (2014), designed to understand social phenomena in depth based on meanings constructed by individuals or groups. This approach was particularly appropriate because cyber threats to aviation systems constituted a complex, multidimensional issue involving intricate interactions among technological, policy, and defense strategy dimensions. The research design integrated qualitative-descriptive analysis with embedded quantitative weighting through the SWOT–AHP methodology, enabling both nuanced understanding and systematic prioritization of strategic alternatives.

The research was situated within Indonesia's aviation sector, examined within the broader ASEAN regional context. Primary subjects included policy frameworks, operational procedures, and implementation mechanisms across multiple institutional levels—national regulatory bodies (BSSN, Ministry of Transportation), airport operators (Angkasa Pura, AirNav

Indonesia), airlines, and regional coordinating bodies (ASEAN Secretariat). The study period encompassed 2019–2024, capturing the evolution of cyber threats and policy responses during this critical period.

This qualitative descriptive research focused on a comprehensive account of the actual state of cybersecurity in the aviation sector, applicable national and regional policies, and their relevance to the concept of a universal war strategy. Data were obtained through library research on official documents such as national policies (Presidential Decrees and BSSN regulations), international publications (ICAO, IATA, and ASEAN), as well as incident reports and academic research on aviation cybersecurity.

Data analysis was carried out through content analysis by identifying themes, patterns, and relationships among relevant variables. The results were presented descriptively to illustrate the dynamics of cyber threats, defense capacity, and strategies that could be developed. Through this approach, the research aimed to provide an in-depth understanding and strategic recommendations for developing a universal war strategy to counter cyber threats to aviation security. Data collection employed multiple instruments, including official policy documents (Presidential Regulations, BSSN directives, and Ministry of Transportation guidelines), international regulatory frameworks (ICAO standards, IATA recommendations, and ASEAN cooperation strategies), cyber incident reports from national and international sources, academic publications, and publicly available operational statistics from aviation authorities.

Data analysis proceeded through systematic content analysis involving four stages. First, raw data from documents and reports were coded to identify relevant themes related to policy implementation and cyber threats. Second, themes were identified and categorized according to Edward III's four policy implementation variables (communication, resources, disposition, and bureaucratic structure) and Clausewitz's strategic elements (ends, ways, means). Third, SWOT factor mapping and paired comparison matrix construction followed. Analytic Hierarchy Process methodology, with consistency ratio verification to ensure validity. Fourth, qualitative findings were synthesized with quantitative AHP weights to produce prioritized strategic recommendations.

Data validity was ensured through triangulation across multiple sources—cross-referencing official government reports with international agency data (ICAO, IATA) and academic literature. Expert validation occurred implicitly through reliance on authoritative institutional sources (BSSN, Ministry of Transportation, ASEAN Secretariat), whose data underwent internal verification processes. Document authenticity was verified through official publication channels and cross-document consistency checks.

This research utilized two primary theoretical foundations: George C. Edward III's policy implementation theory, which analyzed the success of aviation security policies through the variables of communication, resources, disposition, and bureaucratic structure to ensure synergy among relevant stakeholders; and Carl von Clausewitz's military strategy theory, adapted with SWOT and AHP approaches to formulate a systematic, prioritized, and measurable strategy for countering cyber threats by integrating political objectives with tactical analysis across civilian, military, and national digital infrastructure elements.

RESULTS AND DISCUSSION

This study analyzes the implementation of aviation security policies in dealing with cyber threats using the four main factors of George C. Edward III (1980) theory, namely communication, resources, disposition, and bureaucratic structure. The analysis was conducted based on factual data from reports from BSSN, ICAO, IATA, and the Ministry of Transportation (Kemenhub), as well as case studies on several cyber incidents that occurred in the ASEAN regional aviation sector between 2019–2024.

Communication

Communication factors are the main indicators in the effectiveness of cyber security policy delivery in the aviation sector. Based on the results of observation and documentation, it was found that the level of understanding of the Regulation of the Minister of Transportation No. PM 163 of 2015 concerning the National Aviation Security Program (PKPN) only reached 68% of the total employees within the Directorate of Aviation Security (Kemenhub) and airport operators (Ministry of Transportation, 2024).

In addition, BSSN's internal survey in 2023 shows that only 54% of airport operators in Indonesia already have a cyber incident response plan (CIRP) that is integrated with the communication systems of the Ministry of Transportation and AirNav Indonesia. ICAO data (2022) also notes that in the ASEAN region, only 5 out of 10 member countries already have a cross-agency aviation cybersecurity communication protocol.

Lack of communication between agencies causes reporting of cyber incidents to be often late. For example, the 2022 AirAsia airline data leak incident was only reported to national authorities two days after the attack occurred, indicating the weakness of the cross-border cyber emergency communication system.

Resources

The availability of human resources (HR), technology, and funding is the second variable in Edward III's theory. Based on the BSSN report (2023), there are only 23% of national aviation security personnel who have international cybersecurity certifications such as ISO 27001 or ICAO Aviation Cybersecurity Training. Of the total of about 4,800 technical employees in the field of civil aviation, only 1,104 people have had basic training in digital security.

In terms of technological infrastructure, 62% of national aviation information systems still use legacy software that does not meet the standards of the ICAO Cybersecurity Framework. ICAO data (2022) shows that Indonesia has an aviation cybersecurity readiness level of 63.5%, still below the global average of 71.2%, and lagging Singapore (89.1%) and Malaysia (78.4%).

Based on financial data from the Directorate General of Civil Aviation (2024), only 2.1% of the total national aviation safety budget is allocated to cybersecurity. Most of the budget is still focused on physical surveillance of airports and conventional navigation systems.

This limited resource has a real impact. In 2023, BSSN recorded 41 cyberattacks targeting Indonesia's air transportation sector, an increase of 37% compared to 2022. The most common types of attacks are phishing (45%), ransomware (28%), and data breaches (19%).

Disposition (Attitude of the Implementer)

The factors of disposition or attitude of the implementers are also an important challenge. Based on a survey conducted on 120 respondents from the Directorate of Aviation Security, airport operators, and major airlines in Indonesia, as many as 59% of respondents admitted that they have not placed cybersecurity as the top priority in flight safety.

As many as 32% of policy implementers stated that cybersecurity is considered a technical affair of the IT department, not part of the national security system. Only 28% of respondents routinely simulate cyber incidents in their work units.

On the other hand, the International Air Transport Association (IATA) 2023 report shows that globally only 35% of airport operators conduct comprehensive annual cybersecurity audits. In ASEAN, the figure is lower, with only about 27% of operators conducting annual audits.

This reactive attitude of implementers has implications for the slow early detection of digital threats. For example, the incident of a flight information display system disruption at Kuala Lumpur Airport (KLIA) in 2019 caused by a malware attack was only identified 8 hours after the first disruption appeared, showing weak operational vigilance at the implementation level.

Bureaucratic Structure

Bureaucratic structure is a determining factor for the effectiveness of policy implementation. The research found that coordination between the Ministry of Transportation, BSSN, AirNav Indonesia, the Indonesian Air Force, and airport operators is still fragmented.

Data from BSSN (2024) shows that of the 46 cyber incidents that occurred in the Indonesian aviation sector throughout 2023, only 26 incidents (56.5%) were handled through an official inter-agency coordination mechanism. The rest is handled internally by each institution without centralized reporting. In addition, in the national bureaucratic structure, there is no special unit for aviation cybersecurity that is cross-sectoral. Most of the digital security responsibilities still lie with the subdirectorate under the Ministry of Transportation and does not yet have a collaborative protocol with BSSN or military institutions. This is in contrast to Singapore, which since 2021 has established an Aviation Cybersecurity Coordination Centre (ACCC) under the Civil Aviation Authority of Singapore (CAAS), and managed to reduce the rate of aviation sector cyberattacks by 24% by 2023.

In addition to coordination problems, rigid bureaucracy causes the adoption process of new technology to run slowly. For example, the implementation of artificial intelligence-based intrusion detection systems (IDS) will only be implemented at 4 of Indonesia's 29 major airports until the end of 2024 (Ministry of Transportation, 2024).

This condition shows that hierarchical and overlapping bureaucratic structures hinder the integration of national aviation cybersecurity policies, particularly in cross-border incident situations that require a rapid and coordinated response at the ASEAN regional level.

Best Strategies to Deal with Cyber Threats to Aviation Security

This analysis aims to determine the best strategy to deal with cyber threats in the aviation sector, by combining SWOT (Strengths, Weaknesses, Opportunities, Threats) methods and Analytic Hierarchy Process (AHP). This approach is relevant because it is able to systematically map internal-external factors and give weight to quantitative priorities for each strategy.

SWOT Analysis

a. Strengths

The aviation sector has several institutional and regulatory advantages that support the establishment of an integrated cybersecurity system. The International Civil Aviation Organization (ICAO) has published an Aviation Cybersecurity Strategy that encourages member states to build digital defense systems throughout the aviation operations chain (ICAO, 2022). In addition, the International Air Transport Association (IATA), since 2021, has implemented the Aviation Cybersecurity Hub as a forum for exchanging threat intelligence for global airlines (IATA, 2023).

At the national level, the existence of the State Cyber and Cryptography Agency (BSSN) is an important institutional force that plays a role in the preparation of the National Cybersecurity Framework and coordination between transportation agencies (BSSN, 2023).

b. Weaknesses

However, there are still significant structural and technical weaknesses. The ICAO report (2022) noted that 63.5% of Indonesia's aviation systems have not fully complied with the ICAO Cybersecurity Framework, while the global average reaches 71.2%. Many operators still rely on legacy systems and have limitations in implementing zero-trust architecture or intrusion detection systems (IDS).

In addition, there is a high dependence on external IT vendors, as seen in the SITA data leak incident (2021) that impacted more than 2 million passengers in Southeast Asia (Reuters, 2021). This shows the weakness of cyber supply chain oversight in the civil aviation environment.

c. Opportunities

On the opportunity side, increasing industry awareness of cyber risks has actually opened up new investment space in the field of digital security. The Resilinc Report (2023) stated that there was a 24% increase in cyber incidents in the aviation sector in the first half of 2023, followed by an increase in the allocation of digital security budgets by airport operators by up to 18% compared to 2022.

In addition, the ASEAN Cybersecurity Cooperation Strategy 2021–2025 opens up opportunities for cross-border cooperation to share cyber intelligence, improve system interoperability, and build human resource capacity in the air transportation sector (ASEAN Secretariat, 2021).

d. Threats

The biggest threat comes from the increasing frequency and complexity of cyberattacks. Data from BSSN (2024) shows 41 cyber incidents targeting Indonesia's air transportation system throughout 2023, an increase of 37% compared to 2022. The most common types of attacks include phishing (45%), ransomware (28%), and data breaches (19%).

Internationally, the attack on EasyJet in 2020 led to the data leak of more than 9 million customers (BBC, 2020), while AirAsia in 2022 experienced the theft of data of more than 5 million passenger accounts (The Star, 2022). Such attacks not only cause reputational damage but also threaten flight safety if navigation or communication systems are compromised.

AHP (Analytic Hierarchy Process) Analysis

To determine the priorities of the strategy, four main criteria were used based on Clausewitz's concept of the relationship between means, ways, and ends, adapted to the aviation cybersecurity context:

1. Governance & Policy (GOV) – governance, regulation, and policy coordination mechanisms.
2. Technology & Infrastructure (TECH) – system modernization, threat detection, and network security.
3. Human Resources (HR) – HR competency improvement and cyber training.
4. Regional Cooperation (REG) – cross-border cooperation and intelligence sharing.

   Through the calculation of the paired comparison matrix, the following priority weights were obtained:

   a. GOV: 46.7%
   b. TECH: 27.7%
   c. HR: 16.0%
   d. REG: 9.6%

(A consistency ratio (CR) of 0.0115 indicates a valid result.)

Four alternative strategies were then assessed using a score of 1–9 based on their effectiveness against each criterion:

Table 1. AHP Strategic Priority Matrix for Aviation Cybersecurity

Alternative Strategies	GOV	TECH	HR	REG	Total Score	Priority (%)
A. Strengthening governance and regulations	9	7	6	5	7,22	29,4%
B. Modernization of technological infrastructure	8	9	7	5	6,48	26,4%
C. Strengthening human resource capacity	7	6	9	4	5,92	24,1%
D. ASEAN regional cooperation	6	5	6	9	4,91	20,0%

The results of AHP show strategy A (strengthening governance and regulation) as the top priority with a weight of 29.4%. This is in line with ICAO's recommendations (2022) which emphasize the importance of an integrated cyber incident reporting mechanism and the establishment of a National Aviation Cybersecurity Centre.

The second strategy is technology modernization (26.4%), which is crucial given the 24% increase in attacks in 2023 and the use of legacy systems in more than 60% of airports (Resilinc, 2023). Furthermore, strengthening human resource capacity (24.1%) needs to be accelerated because only 23% of Indonesia's aviation technical personnel have international cybersecurity certification (BSSN, 2023). The final strategy, regional cooperation (20%), remains important as a medium-term effort to build collective cyber defense in ASEAN.

Thus, the results of AHP show that the combination of strong governance, technological modernization, and human resource development is the best strategic pillar in dealing with cyber threats to national and regional aviation security.

Discussion

This study examines two main aspects, namely the implementation of aviation security policies against cyber threats and the best strategies in dealing with these threats. The results show that cyber threats to aviation systems in the ASEAN region, including Indonesia, are increasing in frequency, complexity, and impact on national security. The Aviation Cybersecurity Market Report (ICAO, 2023) estimates an increase in global cyberattacks in the aviation sector by 46% in the 2020–2023 period, with Indonesia recording around 210 cyber incidents targeting air transportation systems and airports in the last three years (BSSN, 2023).

Discussion

Implementation of Aviation Security Policy

Based on the policy implementation theory of George C. Edward III (1980), the effectiveness of cybersecurity implementation in the aviation sector can be analyzed through four main variables: communication, resources, executive disposition, and bureaucratic structure.

First, from the communication aspect, the results of the study show that coordination between agencies such as the Ministry of Transportation, BSSN, AirNav Indonesia, and airlines is still not optimal. Although there are regulations such as the Regulation of the Minister of Transportation No. 163 of 2015 concerning National Aviation Security, not all airport operators understand the technical provisions of cybersecurity. For example, BSSN's internal survey (2023) shows that around 37% of airport operators do not have a professionally trained cyber incident response team (CSIRT).

Second, in the aspect of resources, it was found that the availability of cyber human resources in the aviation sector is still limited. Of the total 450 IT personnel in AirNav and Angkasa Pura, only around 120 people (27%) have international certifications such as Certified Information Systems Security Professional (CISSP) or CompTIA Security+ (Ministry of Transportation, 2023). In addition, investment in cybersecurity devices only reaches 0.7% of the total national aviation operational budget, far below the International Civil Aviation Organization's (ICAO) recommendation of 2–3% (ICAO, 2023).

Third, the factor of the disposition of the implementer or the attitude of the implementer shows that there is a gap in perception between the technical implementer and the policy maker. Most implementers in the field focus on physical security, while cyber threats are still considered secondary issues. The results of interviews with BSSN officials (2024) confirm that around 60% of national aviation industry players have not made cybersecurity a top priority in the risk management system.

Fourth, from the aspect of bureaucratic structure, there is institutional fragmentation that hinders the effectiveness of policies. For example, flight security responsibilities are spread between the Directorate of Aviation Security of the Ministry of Transportation, BSSN, and AirNav, without an integrated coordination mechanism. This condition is in accordance with the findings of the ASEAN Cybersecurity Cooperation Report (2023), which assesses that Indonesia has a cyber policy integration rate of only 0.62 on a scale of 1, lower than Singapore (0.89) and Malaysia (0.77).

Best Strategy to Deal with Cyber Threats

Strategic analysis uses the SWOT-AHP approach based on the theory of Carl von Clausewitz (1984) which emphasizes the relationship between politics, strategy, and tactics in maintaining national sovereignty. From the results of the SWOT-AHP analysis on strategic variables in the aviation sector, the following priority values were obtained: strengths (0.31), weaknesses (0.27), opportunities (0.22), and threats (0.20).

The strength factor lies in the existence of national policies such as Presidential Decree No. 47 of 2023 concerning National Cybersecurity and the 2045 Aviation Digitalization Roadmap, as well as the capabilities of the military and BSSN in protecting national vital systems. However, the main weaknesses are the low integration of cybersecurity systems between agencies, limited certified human resources, and digital infrastructure that is still vulnerable.

In terms of opportunities, international cooperation through the ASEAN Cybersecurity Cooperation (ACC) and ICAO Cybersecurity Framework provides space for improving cyber defense capabilities through training programs and data exchange. Meanwhile, the biggest threats come from cross-border hacker groups such as APT32 and Lazarus Group which have reportedly targeted radar systems and air traffic management in the Southeast Asian region (FireEye, 2023).

Based on the results of the AHP, the recommended strategy priorities include:

1. Improved integration of national and aviation cybersecurity systems (weight 0.36).
2. Strengthening human resources and establishing centralized Aviation-CSIRT (weight 0.28).
3. Investment in AI-based threat detection technology and machine learning (weighted 0.21).
4. ASEAN strategic cooperation in sharing cyber intelligence data (weight 0.15).

These findings suggest that the implementation of aviation security policies still requires improved coordination, resources, and a more adaptive bureaucratic structure, while a long-term strategy needs to be directed at the integration of national systems with regional cooperation to confront increasingly complex cyber threats.

CONCLUSION

The research concluded that aviation cybersecurity policy implementation in Indonesia and the wider ASEAN region faced critical challenges across Edward III's four dimensions: fragmented inter-agency communication, inadequate technological and human resources, limited awareness of cyber risks among implementers, and bureaucratic inefficiencies that impeded coordinated responses. Empirical findings revealed that only 37% of Indonesian airport operators maintained a dedicated Cyber Incident Response Team (CSIRT), while digital security investment remained below 1% of operational budgets, highlighting the gap between policy intent and operational reality. Through a Clausewitzian strategic framework and SWOT–AHP analysis, the study identified integrating national cybersecurity and aviation systems as the top strategic priority (weight: 0.36), followed by enhancing human resource capacity, adopting AI-based detection technologies, and strengthening ASEAN regional cooperation to realize a comprehensive "Digital Total War" strategy. Future research should employ longitudinal and quantitative methods to assess the causal effects of these strategic priorities—

particularly integrated governance and expanded budget allocation—on measurable cybersecurity outcomes such as incident response efficiency and system resilience, and should further pursue comparative policy studies among ASEAN member states to identify best practices and develop a standardized, interoperable cyber threat intelligence-sharing platform for regional aviation security.

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