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Development of Unmanned Aircraft System of the TNI AL in Intelligence, Surveilance and Reconnainance for Security Operations in Papua

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ABSTRACT

This study analyzes the development of Unmanned Aircraft Systems (UAS) by the Indonesian Navy to enhance intelligence, surveillance, and reconnaissance (ISR) capabilities in the Papua region, which faces complex security challenges. Using qualitative methods through literature review and expert interviews, data were validated via triangulation. The findings show that UAS deployment has significantly improved real-time intelligence gathering and rapid threat response while minimizing risks to personnel. The study recommends continued investment in UAS technology, enhanced personnel training, and stronger inter-agency collaboration to optimize security operations in Papua.

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INTRODUCTION

Papua is one of the regions in Indonesia that has complex and diverse security challenges. These challenges are caused by various factors, including difficult-to-reach geographical conditions, the presence of armed groups, and social conflicts that occur in several areas. Therefore, the Indonesian Navy (TNI AL) has a strategic role in maintaining security and stability in this region. To support security operations, the TNI AL requires sophisticated technology that can increase the effectiveness and efficiency in carrying out intelligence, surveillance, and reconnaissance (ISR) tasks.

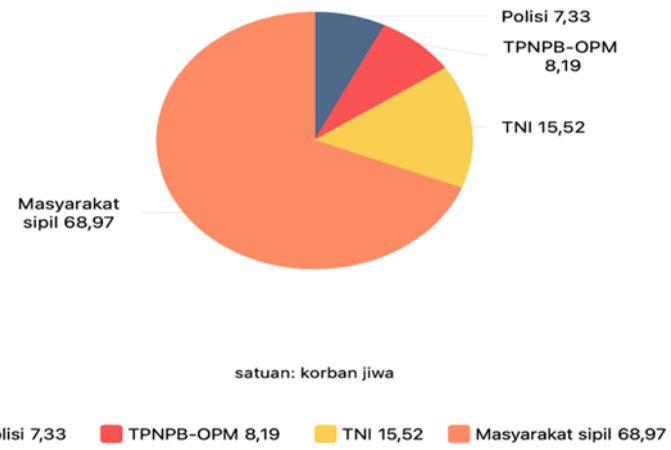

Figure 1. Graph of the number of fatalities in cases of violence in Papua (2010-March 2022)
(Source: Reza Pahlevi Databoks, 2022)

According to a research report from the Papua Task Force of Gadjah Mada University (UGM), there were 348 violent incidents in Papua and West Papua Provinces between 2010 and March 2022. These incidents resulted in 464 fatalities, with the majority of victims, 320 people (69%), being civilians. In addition, 106 victims came from the security forces, consisting of 72 TNI members and 34 Police. There were also 38 fatalities from the OPM.

The use of *Unmanned Aerial Systems* (UAS) is developing as a strategic solution to address complex security challenges. With its rugged topography, from dense forests to high mountains, Papua is often difficult to reach by land, so UAS offers a more efficient approach to monitoring the area. According to Fotohi (2023), UAS is capable of conducting continuous monitoring, collecting accurate intelligence data, and providing *real-time information* to military command. The use of UAS in several military operations has proven effective in various countries and in various conflict situations. In line with what Kotian (2022) said, the use of UAS in monitoring coastal areas has a role in maintaining security. Therefore, the development and implementation of UAS by the Indonesian Navy is a must to improve ISR capabilities in security operations in Papua.

In the future, the utilization of UAS can include the development of optimal network infrastructure and control centers, allowing for efficient

monitoring of remote areas. Juditha & Islami (2018) stated that the strategy of developing information and communication technology (ICT) has the potential to improve ICT infrastructure, increase digital literacy, and strengthen the technology ecosystem in rural Papua. Artificial intelligence (AI) technology on UAS will support *real-time data analysis,* providing accurate reports for policy makers. In addition to operational efficiency, the implementation of UAS must consider social aspects, such as privacy and local community participation. By involving the community in the operation and policy of UAS, the potential for distrust can be reduced. It is hoped that UAS will be able to provide sustainable and accurate security solutions for Papua, without ignoring the privacy rights and local wisdom of its people.

This study aims to analyze the development of UAS by the Indonesian Navy in the context of ISR. Specifically, this study explores two aspects of how to provide strategic recommendations for the development of UAS in supporting security tasks in the Papua region through evaluating the effectiveness of UAS in improving the ISR capabilities of the Indonesian Navy.

LITERATURE REVIEW

Research on the use of Unmanned Aircraft Systems in military operations has been widely conducted and shows various advantages in the field of ISR. According to Sarjito & Lelyana (2023), UAS excels in providing real-time information and increasing situational awareness, which are important aspects for the success of a military operation. UAS has been shown to increase the effectiveness of military operations in many places, such as Afghanistan and Iraq. (Utama & Anwar, 2021).

In the Indonesian context, the use of UAS by the Indonesian Navy is still relatively new. However, several studies have shown the great potential of this technology. For example, research by Yanuar, T. (2021) revealed that UAS can help the Indonesian Navy in monitoring vast waters and finding illegal activities such as smuggling and illegal fishing. In addition, a study by Holly & Colgren (2006) stated that UAS can be used for ISR operations in remote and hard-to-reach areas, such as Papua, where geographical constraints and isolation often hinder conventional operations.

Table 1. State of the art research table

NO	TITLE	WRITER	YEAR	JOURNAL	PREVIOUS RESEARCH	THIS RESEARCH
1	Countering Unmanned Aerial Systems (UAS) in Military Operations	Konrad Dobija	2023	Safety & Defense	This study discusses the challenges and technologies required to address threats from UAS in military operations, especially	This study discusses the challenges and UAS technologies needed to address security threats in Papua.

NO	TITLE	WRITER	YEAR	JOURNAL	PREVIOUS RESEARCH	THIS RESEARCH
					against swarm attacks and autonomous technologies.	
2	Systematic Review on Civilian Drones in Safety and Security Applications	Khalifa Al-Dosari, Z. Hunaiti, W. Balachandran	2023	Drone	Reviewing the use of drones for civil security, including tracking, rescue, and infrastructure monitoring, as well as the risks to privacy and security.	Reviewing the use of UAS for Papua regional security with ISR.
3	Mobile Military Security with Concentration on Unmanned Aerial Vehicles	W. Dufrene	2005	24th Digital Avionics Systems Conference	Focuses on military mobile security using UAVs, including applications for homeland security and mission risk mitigation.	Focusing on the security and stability of the Papua region using UAS.
4	Security of Unmanned Aerial Vehicle Systems against Cyber-Physical Attacks	C. Rani, H. Modares, R. Sriram, D. Mikulski, F. Lewis	2016	Journal of Defense Modeling and Simulation	Reviewing cyber attacks on UAVs, particularly the threat of unauthorized access to UAV sensor data, and defense strategies against such attacks.	Reviewing OPM attacks, topographic and geographic obstacles faced by UAS
5	Counter-Unmanned Aircraft System(s) (C-	Jian Wang, Yongxin Liu, H. Song	2020	IEEE Aerospace and Electronic	Provides a comprehensive survey of C-UAS technology, including	Providing ISR data in Papua region security operations from the use of UAS.

NO	TITLE	WRITER	YEAR	JOURNAL	PREVIOUS RESEARCH	THIS RESEARCH
	UAS): State of the Art, Challenges, and Future Trends			Systems Magazine	detection, identification, and mitigation of UAVs deemed a threat to public safety.	
6	Drone Secure Communication Protocol for Future Sensitive Applications in Military Zone	Yongho Ko, Jiyoon Kim, Daniel Gerbi Dugum a, P. Astillo, I. You, G. Pau	2021	Sensors (Basel, Switzerland)	This study discusses secure communication protocols for UAVs in military zones, including solutions to the threats of jamming and spoofing attacks.	This study discusses solutions to the threat of jamming and spoofing attacks in security operations using UAS.

The use of UAS in security operations continues to grow with significant findings. Recent studies have highlighted the major challenges in addressing UAS threats, especially when facing swarm attacks and autonomous drones that are difficult to counter by current defense systems (Dobija, 2023). Civil security is also greatly impacted by the use of drones, especially in tracking and monitoring infrastructure, which poses new risks to public privacy and security (Al-Dosari et al., 2023). In the military context, UAVs play a critical role in mobile security and risk mitigation during homeland security operations (Dufrene, 2005). However, this technology is vulnerable to cyberattacks, with a high risk of UAV sensor data infiltration, necessitating the development of effective defense strategies (Rani et al., 2016). In addition, Counter-UAS technology is important in detecting and disabling UAVs that are considered threats (Wang et al., 2020). On the other hand, secure communication protocols in military zones have been developed to protect UAVs from attacks such as jamming and spoofing, to strengthen data security and UAV control in the field of operations (Ko et al., 2021). From all the literature studies above, they have *a state of the art* with this study providing a new relevant perspective, so that it requires several supporting theories in this study, namely:

Military Technology Theory

Military technology theory, as described by Van Creveld (1989), focuses on how technological developments can be used to enhance military capabilities and operational effectiveness. UAS technology, as one of the innovations in

military technology, provides strategic advantages with its ability to conduct continuous surveillance and collect precise intelligence data. This theory explains that the adoption of new technologies, such as UAS, can change military tactics and strategies and increase competitiveness in asymmetric conflicts (Mohsan, et.al., 2023; Choi & Kim, 2023).

The application of UAS technology in ISR operations in Papua is in line with the principles of military technology theory, through the ability to operate in remote and hard-to-reach areas, UAS can provide significant tactical advantages. This is especially relevant considering the complex and challenging geographical conditions of Papua. Studies show that UAS can better and more accurately monitor areas that were previously difficult to monitor by conventional ground or air forces (Liu, 2020; Davis & Smith, 2023).

The navy can detect illegal activities such as smuggling and illegal fishing, which often occur in vast and difficult-to-reach waters, thanks to the use of UAS. (Setiawan et.al., 2022). In addition, UAS can also monitor armed groups in mountainous areas well, providing military commands with real-time data that is crucial for planning security operations. (Sigala & Langhals, 2020; Lewis & Turner, 2023).

Conflict Management Theory

Conflict management theory, as outlined by Burton (1990), provides a framework for understanding how technology can be used to manage and defuse conflict. In the context of security operations in Papua, UAV systems can help track the movements of armed groups and provide the intelligence needed to plan effective and safe operations. (Bojor & Grigore, 2024).

According to Galtung (1996), effective conflict management requires accurate and up-to-date information about the situation on the ground. UAS, with its ISR capabilities, can provide this information in real-time, enabling a rapid and appropriate response to security threats. Integration of UAS technology into conflict management strategies in Papua can help reduce tensions, prevent escalation of violence, and increase stability in the region (Dobija, K., 2023).

UAS enables early threat identification with its ability to conduct continuous surveillance and collect intelligence data in real-time. In the study, it was stated that Heidarlou, HB, et.al. (2020) in areas that are difficult to reach with natural obstacles, such as mountains and dense forests, are obstacles to the smooth running of a military mission, so that the natural conditions of Papua make data collection by UAS unhindered, this is then used to plan military activities in restoring security that is more effective and minimizes risk.

METHODOLOGY

Qualitative Methods

This study uses a qualitative method to deepen the understanding of the use of *Unmanned Aerial Systems* in *Intelligence, Surveillance, and Reconnaissance* as well as military and security operations. This method involves two main techniques, namely: literature study and in-depth interviews. Literature study is used to collect information from relevant sources such as scientific journals,

books, and official documents related to the research variables, especially in the context of UAS in the field of ISR and military security operations. Meanwhile, in-depth interviews were conducted with TNI AL officials and personnel at Puspenerbal who have direct experience in ISR operations in Papua. This interview aims to gain deeper insight into the challenges faced, benefits, and impacts felt from the use of UAS in these security operations.

Research Procedures

The research procedure consists of three main steps, namely: data collection, data analysis, and validation of findings. Data collection was carried out through literature studies, in-depth interviews, and surveys during the specified research period. The main data sources include official TNI AL documents, operational reports, and interviews with military personnel and related experts. The qualitative data obtained were then analyzed using descriptive-analytical thematic analysis techniques to identify key themes and patterns that emerged from the results of interviews and literature. Validation of findings was carried out using data triangulation techniques, where results from various methods were compared and verified to ensure the accuracy and consistency of research findings. This technique provides greater confidence in the research results and ensures that the conclusions drawn reflect field conditions objectively.

RESEARCH RESULT AND DISCUSSION

Identification of Challenges and Needs in UAS Development for ISR Operations in Papua

Papua, with its challenging geographical conditions, requires a mature strategy for effective *Unmanned Aircraft System operations* to support security. According to conflict management theory, managing conflicts that occur in vulnerable areas, such as Papua, requires an approach that prioritizes monitoring and preparedness for threats. UAS, as a remote surveillance technology, can support conflict management through continuous and real-time monitoring capabilities, enabling faster and more responsive decision-making to reduce tensions and the risk of direct conflict. However, the geographical conditions consisting of dense forests, high mountains, and remote areas that are difficult to reach complicate the mobility and stability of UAS. Therefore, the UAS technology used must be able to adapt to harsh terrain and extreme weather, such as heavy rain and strong winds, so that it can continue to operate and function optimally in surveillance in the dynamic Papua region (Feng & Zhang, 2023; Inoue & Nakamura, 2023).

From the perspective of military technology theory, technological innovation applied to UAS for intelligence and surveillance purposes must continue to develop in line with the demands of the operational field. UAS optimized for Papua requires hybrid technology that combines battery and fuel power to extend its operational time, given the wide coverage area and the rare access to charging infrastructure in remote areas. Sensor and communication technology also play a vital role in ensuring that the collected data can be processed immediately and sent to the command center without any obstacles.

Modern military technology prioritizes the development of efficient, accurate, and easily accessible systems in difficult field conditions. In addition to a precise and reliable navigation system, anti-interference technology is needed to maintain the stability and security of data communications, especially in areas with minimal communication infrastructure (Hutomo et al., 2022).

The successful implementation of UAS technology in Papua also requires adequate human resource readiness and supporting infrastructure. In conflict management theory, human resource skills and readiness are very important in anticipating and responding to threats appropriately. UAS operators need to receive intensive training that includes operating techniques in difficult terrain, system maintenance, and data analysis capabilities. In addition to training, supporting infrastructure such as control stations, communication systems, and data processing software need to be improved to achieve overall UAS operational effectiveness. With adequate training and infrastructure support, UAS can function as a vital tool in supporting security operations in Papua, enabling the Indonesian Navy to carry out surveillance missions more efficiently and accurately and strengthen security stability in the region (Xu & Chen, 2023).

Evaluation of the Effectiveness of UAS in Improving the ISR Capability of the Indonesian Navy

The use of UAS by the Indonesian Navy has had a significant impact on increasing situational awareness in the field, especially in security operations in Papua. UAS provides the ability to obtain *real-time intelligence data* that is very helpful in detecting and identifying threats quickly. From the interview results, the majority of respondents stated that UAS is very effective in understanding the field situation and anticipating emerging risks, supporting the findings put forward by Keller et al. (2020). UAS can fly at high enough altitudes to conduct extensive surveillance and are not easily detected by potential threats, thus offering a strategic advantage that other technologies do not have. With this capability, UAS is able to play a role in providing data to improve security and preparedness in high-risk areas.

Table 2. Summary table of interviews on the effectiveness of UAS use

No	Respondents	Position/Title	Effectiveness of UAS Usage	Additional information
1	Respondent 1	Ditops	Very Effective	UAS helps detect illegal vessels quickly
2	Respondent 2	Commander of KRI 1	Very Effective	Reduces the need for manual patrols, wider coverage
3	Respondent 3	Commander of KRI 2	Effective	Effective in good weather conditions, needs sensor improvement
4	Respondent 4	Air wing commander	Very Effective	Easy to operate and provides real-time data

No	Respondents	Position/Title	Effectiveness of UAS Usage	Additional information
5	Respondent 5	UAS Operator 1	Effective	Helps analyze threat movement patterns
6	Respondent 6	UAS Operator 2	Very Effective	Efficient in detecting suspicious activity in open waters
7	Respondent 7	UAS Operator 3	Very Effective	Wide area coverage, able to work at night
8	Respondent 8	Commander Ron UAS	Effective	Useful for quick identification but requires refinement of AI algorithms
9	Respondent 9	UAS Technician 1	Very Effective	Very helpful in rescue operations and routine patrols
10	Respondent 10	UAS Technician 2	Effective	Effective but requires human supervision as a companion

The superiority of UAS in collecting precision intelligence data reflects the main principles of military technology theory, which emphasizes improving the ability of detection, surveillance, and detailed data collection to support rapid and accurate decision making. Equipped with advanced sensors and high-resolution cameras, UAS are able to produce high-quality visual data that allows for in-depth and comprehensive analysis. This technology helps the Indonesian Navy identify movement patterns or changes in the operational field, both visible and hidden, thus providing an in-depth situational picture. According to military technology theory, this superiority makes UAS a key instrument in modernizing defense strategy, where technology-based intelligence enables the Indonesian Navy to develop more efficient and data-driven operational strategies. This technology, as stated by Agbeyibor et al. (2024), is the foundation for more effective operational planning, ensuring that every step is based on accurate and reliable information.

The ability of UAS to provide real-time intelligence enhances operational effectiveness through rapid response to potential threats, an approach rooted in conflict management theory. Rapid response in identifying and addressing threats allows for a more proactive reduction in the potential for conflict escalation. In the context of Papua, where threats can emerge suddenly and situations often require quick decisions, real-time data from UAS reduces the time lag between detection and action, which often determines the success of operations. This is in line with the principles of conflict management, where effective conflict management requires continuous surveillance and the ability to act quickly to prevent conflict from escalating. The ability of UAS to respond quickly to threats not only enhances the effectiveness of the Indonesian Navy in the field, but also provides a tactical advantage that can prevent critical situations from escalating further (Fan et al., 2020).

As a military technology tool, UAS also reduces risk to personnel by providing surveillance and response capabilities that do not require direct physical involvement, which is particularly relevant in security operations in high-risk areas. UAS enable safer and more efficient security operations by minimizing personnel exposure to dangerous areas, thereby supporting conflict management objectives in managing security without increasing risk to the parties involved. In situations such as Papua, where armed conflict may be an immediate threat, the use of UAS provides an additional layer of protection for military personnel while still allowing for intensive surveillance and targeted action.

Impact of UAS use on security operations in Papua

The graph below is an indication after the implementation of UAS in security operations in Papua, operational report data shows a significant decrease in illegal activities and attacks by armed groups. This has proven to be an effective technology, as seen in maritime security operations, where the number of illegal fishing has decreased drastically, while the number of attacks by armed groups has also decreased. UAS is very important to keep the region safe because of its ability to detect and act quickly. (Chapapría et.al., 2022). Continuous surveillance and the ability to detect threats from the air provide effective deterrence against illegal activities.

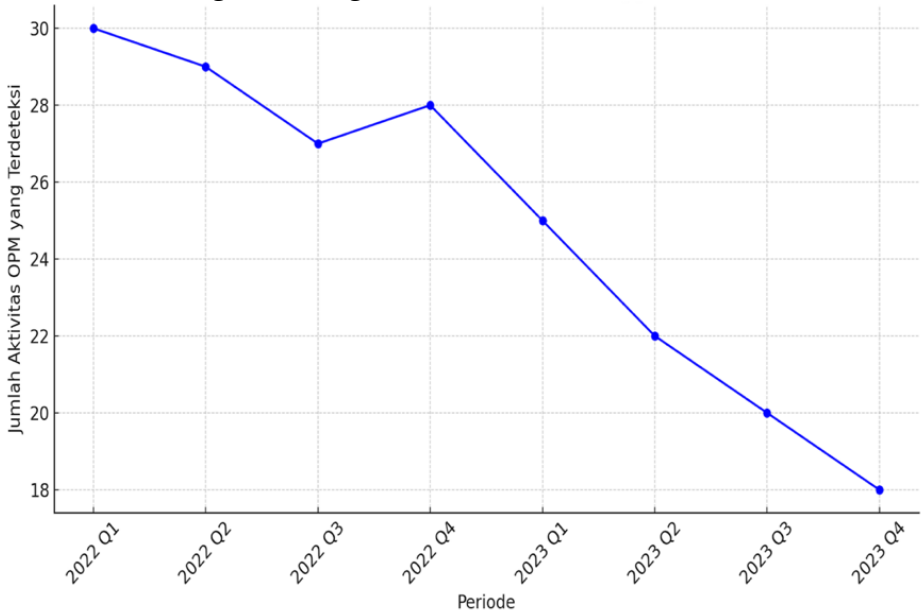

Figure 2. OPM activity graph 2022-223

The use of UAS has helped improve stability in Papua by providing continuous surveillance and accurate intelligence data. As stated by the Air Wing Commander:

"The presence of the Navy UAS significantly helps realize security and a conducive situation in the Papua region. In accordance with the orders of the TNI Commander at that time, we optimized the UAS defense equipment that we have as part of the *Intelligence, Surveillance, and Reconnaissance capabilities*. This

technology allows us to detect threats faster and respond more effectively, so that security stability in Papua can be better maintained."

This allows the Indonesian Navy to identify and respond to threats before they escalate into bigger problems. Continuous surveillance also provides a constant presence, which can suppress illegal activities and reduce tensions in the region (Iskandar, 2022).

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of the research and analysis conducted, several important points can be concluded as follows:

Use of UAS Technology

Papua, which has difficult terrain and extreme weather, requires a special strategy. UAS enables real-time monitoring, reduces potential conflict with rapid response, but demands weather-resistant technology and advanced navigation systems (Feng & Zhang, 2023; Inoue & Nakamura, 2023). According to military technology theory, hybrid systems and efficient sensors are essential for sustainable operations. The success of these operations also depends on intensive training and adequate infrastructure for UAS operators (Xu & Chen, 2023).

Effectiveness of the Indonesian Navy UAS

The effectiveness of security operations in Papua with the use of UAS by the Indonesian Navy has increased situational awareness. UAS, equipped with advanced sensors and high-resolution cameras, are able to provide real-time intelligence data that facilitates fast and accurate threat detection, in line with the theory of military technology that prioritizes speed and precision in intelligence collection (Agbeyibor et al., 2024). According to conflict management theory, UAS supports proactive responses, reducing the potential for conflict escalation through continuous monitoring without involving personnel directly in the field, thereby reducing risks in high-risk operations (Fan et al., 2020).

Impact of UAS on Papua Security

Continuous surveillance by UAS has been able to reduce the activities and incidents of armed separatist groups. According to conflict management theory, UAS functions as a tool that is able to detect threats early and provide a quick response, thus preventing the conflict from developing into something more complicated. Thus, UAS helps prevent the escalation of conflict in vulnerable areas such as Papua, following the principles of conflict management that emphasize the importance of controlling the situation through accurate intelligence and a quick and appropriate response.

Recommendations

Strategic recommendations for UAS Development in Support of Security Tasks in Papua, including strategic recommendations proposed to maximize the benefits of UAS use by the Indonesian Navy: Investment in UAS Technology: Continuous investment in UAS technology is needed to improve flight endurance, operational range, and navigation capabilities. Innovation in sensor

technology and communication systems is also important to ensure more efficient and effective operations; Intensive Training for UAS Operators: Intensive training for UAS operators is essential to ensure safe and effective operations. This training should include operating techniques in adverse weather conditions, system maintenance, and intelligence data analysis; Improvement of Supporting Infrastructure: Investment in improving supporting infrastructure such as control stations and communication systems is essential. Adequate infrastructure will improve the ability of UAS to operate in various conditions and regions, ensuring effective coordination in security operations; Inter-Agency Collaboration: Collaboration between the Indonesian Navy, other security agencies, and local governments is essential to ensure effective coordination in security operations in Papua. This cooperation can include intelligence sharing, mission coordination, and rapid response to threats.

ADVANCED RESEARCH

This study highlights that the strategic use of Unmanned Aerial Systems (UAS) enhances the Indonesian Navy's operational effectiveness in Papua through real-time monitoring, early threat detection, and reduced personnel risk. Supported by advanced sensors and autonomous navigation, UAS helps prevent conflict escalation in line with conflict management theory. Long-term success depends on continuous investment, intensive operator training, adequate infrastructure, and inter-agency collaboration, positioning UAS as a vital component in an intelligence- and technology-driven security strategy.

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