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# Systematic Literature Review on the Implementation of Unmanned Ground Vehicle System (UGVS) for Defense in Indonesia

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***Abstract***
*This research conducts a systematic literature review to examine the implementation of Unmanned Ground Vehicle System (UGVS) in the context of defense in Indonesia. Given the geographical and operational challenges faced by Indonesian military personnel, UGVS offers an innovative solution to improve the efficiency and effectiveness of military and non-military operations. This study considers the application of UGVS that has been adopted in several developed countries, such as the United States, the United Kingdom, Israel, China and Russia, to explore its potential in enhancing Indonesia's defense capacity. The review covers aspects such as the potential of UGVS in enhancing defense capabilities, technical challenges in the integration of UGVS into existing defense systems, and strategies to overcome these challenges. The research also evaluates the performance of UGVS in combat situations and its impact on defense operations. Using a systematic literature review method, this research presents an in-depth analysis of UGVS applications and highlights the need for integration of this technology in Indonesia's defense system to improve operational effectiveness and efficiency.*

***Keywords: UGVS, Defense, Indonesia, Effectiveness, Integration***

## INTRODUCTION

The perception of risk in the world of defense, especially in Indonesia, has created various challenges that must be faced. The main causes can be attributed to the geographical conditions of Indonesia and the consequences of defending the Unitary State of the Republic of Indonesia (NKRI). These two aspects interact in an interrelated manner, where the geographical conditions in Indonesia can cause risks faced by military personnel during various military and non-military operations in certain areas of Indonesia (Ministry of Defense, 2015; Pazli & Iskandar, 2014; Sciascia & Malufti, 2021). Therefore, it is important for us to carefully consider this fact in order to improve the efficiency and effectiveness of these operations. For example, a number of military and non-military operations in Indonesia, such as counterinsurgency operations in Papua, Aceh, and Maluku, counterterrorism, and humanitarian assistance and natural disaster management, show the high risk of conducting operations in environments with very difficult geographical conditions (Bujak Andrzejand Smolarek, 2011; Gultom, 2021; Nainggolan, 2016; Schulze, 2004; Sholeh, 2008). This kind of situation raises various issues that need to be addressed so that the efficiency and effectiveness of military and non-military operations can be significantly improved.

To reduce these risks, appropriate and innovative solutions are needed. One interesting solution to consider is the use of an Unmanned Ground Vehicle System (UGVS). UGVS is an unmanned ground vehicle system that is operated automatically by a human operator remotely (Ahmed et al., 2020; Papadopoulos et al., 2021). Equipped with sensors, cameras, and various other devices, UGVS are able to recognize the surrounding environment, communicate, and perform certain tasks (Gao et al., 2022; Miksik et al., 2011; Williams et al., 2020). The

application of UGVS has been widely adopted by several developed countries, including the United States, the United Kingdom, Israel, China, and Russia. These countries use UGVS in various military roles, such as reconnaissance, patrolling, and military law enforcement (Cohen, 1995; FARRELL, 2008; RIGGS, 2009; Scobell & Nathan, 2012). The use of UGVS offers a number of benefits, such as reduced risk to military personnel, improved mobility and accessibility, and enhanced intelligence capabilities in support of humanitarian assistance and disaster management (Naglak et al., 2021; Weitz, 2023; Yang et al., 2021).

Therefore, a review of the application of UGVS for defense purposes in Indonesia is of interest for further research. This review can be conducted through a systematic literature review method to investigate and evaluate various related aspects. These include the potential of UGVS in enhancing Indonesia's defense capabilities, technical challenges faced in integrating UGVS in the existing defense system, and strategies to overcome these challenges. In addition, this review will also evaluate the performance of UGVS in combat situations and its impact on the efficiency and effectiveness of defense operations in Indonesia. Through this research, it is expected to contribute to the understanding of the potential of UGVS as a solution to improve Indonesia's defense, as well as identify strategies in integrating it in the existing defense system. Thus, the results of this review are expected to support efforts to improve the efficiency and effectiveness of defense operations in both military and non-military contexts in Indonesia.

## RESEARCH METHODS

### Systematic Literature Review

A systematic literature review (SLR) is a literature review method that investigates, evaluates, and analyzes all findings surrounding a research topic to answer predetermined research questions. The SLR method is conducted systematically by following stages and protocols to avoid bias and subjective understanding of the researcher (Ifanov et al., 2023). The objectives of this study are to determine the potential of UGVS in enhancing Indonesia's defense capabilities, identify technical challenges of UGVS integration in the existing defense system and find solutions, and evaluate the performance of UGVS in combat situations and its impact on the efficiency and effectiveness of defense operations in Indonesia. By using SLR, data from hundreds of literature works can be accessed quickly without having to read all of them.

### Research question

The purpose of these research questions is to provide an understanding of the direction and scope of the literature review to be conducted. The research questions also played a role in facilitating data collection. Table 1 summarizes the relevant research questions for this study.

**Table 1.** Research Question

| No | Research Question | Purpose |
|---|---|---|
| **1** | What is the potential of UGVS in improving Indonesia's defense capability? | To find out the potential of UGVS in improving Indonesia's defense capabilities.. |
| **2** | What are the technical challenges faced in integrating UGVS in existing defense systems, and how can they be overcome? | To find out the technical challenges faced in trying to integrate UGVS in existing defense systems, and to find out how to overcome them. |
| 3 | How does the UGVS perform in combat situations and its impact on the efficiency and effectiveness of defense operations in Indonesia? | To find out how UGVS performs in combat situations and its impact on the efficiency and effectiveness of defense operations in Indonesia. |

**Result Discovery**

To answer the existing research questions, this research will conduct a search for previous research papers using the keywords "implementation of Unmanned Ground Vehicle System for defense". The research results found are shown in Table 2.

**Table 2.** Research Result

| No | Database Journal | Number of Articles |
|---|---|---|
| **1** | *Scopus* | 16 |
| **2** | *Journal of Web Semantics* | 12 |
| | *IEEE* | 2 |
| Total | | **30** |

The search for research papers was conducted based on several inclusion and exclusion criteria. Table 3 contains these criteria.

**Table 3.** Inclusion and Exclusion

| Criteria | New students | Change |
|---|---|---|
| **Inclusion** | I1 | Articles published from 2018 to 2023 |
| | I2 | Articles are written in English or Indonesian |
| | I3 | Full-Text Article |
| | I4 | Related to the Implementation of Unmanned Ground Vehicle System for defense in Indonesia. Artikel Tidak |
| **Exclusion** | E1 | The article is not related to Implementation of Unmanned Ground Vehicle System for defense in Indonesia. Similar Articles |
| | E2 | From different databases |

To ensure the paper is not too long and remains relevant to today (I1), it is necessary to vary the learning experience of the author in English and Indonesian (I2). This will also help the paper to be more critical and detailed (I3). In addition, to maintain the focus of the paper (E1) and avoid similarities with other papers (E2), these steps need to be taken (Siswanto, 2010).

## RESULT AND DISCUSSION

**Potensi Unmanned Ground Vehicle System (UGVS)**

UGVS (Unmanned Ground Vehicles) represent a significant evolution in defense innovation, with substantial potential to revolutionize the defense industry in Indonesia. These vehicles, which operate without human intervention, offer two key advantages: mitigation of risk

to personnel and the ability to conduct operations in locations previously considered inaccessible or of high risk. In a technological context, one of the most innovative aspects of UGVS is the implementation of an attitude control system based on an artificial neural network with a backpropagation method. This system, which utilizes principles from machine learning, improves the accuracy and operational responsiveness of the UGVS, enabling rapid adaptation to environmental variables and tactical changes. From a global collaboration perspective, partnerships with technologically advanced countries, such as Japan and the UK, can facilitate access to the latest innovations, cutting-edge technologies and best methodologies in UGVS development. This kind of synergy not only amplifies Indonesia's domestic defense capacity, but also positions it within the global defense network (Hu, X., & Assaad, R. H., 2023; Duraisamy, P., dkk, 2022).

In terms of materiality, the application of composites such as FRP (Fiber Reinforced Polymer) in the UGVS design offers structural advantages. The mechanical characteristics of FRP, which combine strength with light weight, maximize the mobility of the UGVS while maintaining operational efficiency. Furthermore, the integration of high-energy-based weapon technologies, such as the electromagnetic railgun, expands the tactical capabilities of the UGVS, providing a competitive advantage in combat scenarios. Nevertheless, the adaptation of UGVS technology in Indonesia must be calibrated in accordance with national security norms and defined defense needs. A holistic approach combining innovation, collaboration and essential sustainability in the evolution of this defense technology is urgently needed (Krecht, R., Suta, A., dkk,2023; An, D., Krzysiak, R., dkk, 2023).

**Technical Challenges of UGVS integration into defense systems**

The development of autonomous systems, particularly in the context of creating advanced systems for UGVs (Unmanned Ground Vehicles), is a challenge that requires a meticulous technical approach as well as proficiency in advanced software development. The process of creating technology capable of operating a vehicle without human presence requires a deep understanding of various technical aspects, ranging from precise sensors to complex algorithms. Software development is at the core of creating these autonomous systems, where meticulous programming and fully integrated system design are required. Technical skills and in-depth knowledge in this field are essential to achieve a reliable and capable autonomous system. Navigation is a crucial aspect in the development of autonomous ground vehicles (UGVs). UGVs must be able to navigate complex environments autonomously, using advanced sensor technology and computer systems that can perform data processing automatically and without relying on human intervention. Sensors integrated into UGVs are able to detect obstacles, identify the best route, and respond quickly to changes in the environment (Liang, X., dkk, 2021).

In addition, Interoperability, as the suitability of systems to work together, poses substantial challenges in the defense industry sector, especially in the context of cross-border operations. The process of integrating Unmanned Ground Vehicles (UGVs) into the defense system framework requires the use of a model parallel to the Battlefield Management System (BMS) adopted by the Indonesian Army cavalry. However, this requires development on a broader scale, allowing the integration of command and control systems across different branches of the military. This challenge underscores the need for harmonization of communication technologies and protocols to ensure efficient and effective interoperability across defense systems so as to provide a solid foundation for seamless collaboration between devices and systems from different sources. In this development, the focus on integrating UGVs is not just about customizing technologies, but also implementing standards that enable alignment of functions and objectives between different system components, creating synergies between different military branches to achieve operational excellence (Jiang, Y., dkk, 2022).

On the other hand, in the design of communication systems for UGVs (Unmanned Ground Vehicles), communication is at the core that demands special attention. One of the key issues is how to harmonize various components from different manufacturers to interact seamlessly. The challenge arises due to differences in standards, protocols, and technologies used by each manufacturer, which makes integration complex. Proper integration processes and optimized compatibility are key to ensuring that all component elements can communicate seamlessly with each other. A careful and carefully coordinated approach is required so that each part of the system can operate as intended to achieve the desired alignment and performance.

And to connect them all requires the integration of artificial intelligence. However, the integration of artificial intelligence (AI) into unmanned vehicles (UGVs) is an important challenge that demands the application of advanced technical skills. Artificial intelligence in this context requires the ability to analyze the diverse data received from the various sensors embedded in the vehicle. With careful analysis, the AI system must be able to process the information from these sensors and then make the right decisions based on the collected data. This process requires a high level of precision in interpreting varied information, so that the vehicle can operate efficiently and safely without human intervention. This emphasizes the need to develop a reliable artificial intelligence system to support the advancement of unmanned vehicles.

**Effectiveness and efficiency of UGVS performance in defense operations**

The effectiveness and efficiency of Unmanned Ground Vehicle Systems (UGVS) performance in defense operations are critical aspects that determine the success of military missions. UGVS, with their advanced capabilities, offer significant advantages in improving precision and speed of response in combat situations. Without the need for a human crew, UGVS are able to navigate dangerous or hard-to-reach terrain, reducing risk to military personnel and enabling wider and faster deployment. Efficiency is achieved through reduced operation time and increased accuracy in task execution, which in turn results in more economical and strategic use of resources. In the context of defense, the effectiveness of UGVS is seen in its ability to conduct precise surveillance, reconnaissance and attack with minimal risk, which overall enhances defense capabilities and tactical advantage on the battlefield (Beycimen, S., dkk,2023).

The effectiveness and performance efficiency of Unmanned Ground Vehicle Systems (UGVS) in defense operations are not only instrumental in improving precision and speed of response in combat situations, but also in changing the paradigm of traditional military strategy. With the ability to operate in high-risk environments without endangering human lives, UGVS pave the way for safer and more efficient intelligence, surveillance and reconnaissance operations. The use of UGVS significantly reduces the risk of accidents and casualties, enabling deployment in areas previously inaccessible to human personnel, such as terrain that is contaminated or has biological, chemical and nuclear weapons threats (Wang, Z., dkk, 2020).

In addition, the UGVS enables more accurate and real-time intelligence data collection, providing a strategic advantage in making tactical decisions. With the integration of artificial intelligence systems and advanced sensors, UGVS is able to identify, track and evaluate targets with high accuracy, which is crucial in modern military operations. The efficiency of the UGVS is also reflected in the use of operational resources. The reduction in the time required to complete missions, combined with more efficient use of fuel and logistics, contributes to an overall reduction in operational costs.

Furthermore, the adaptability of the UGVS in various operation scenarios-from city surveillance to mountainous terrain exploration-demonstrates its great flexibility. With the ability to be equipped with different types of weapons and equipment, the UGVS can be configured according to mission-specific requirements. This not only increases operational effectiveness but also provides military leaders with diverse tactical options. As such, the UGVS

is not only a vital defense tool in the face of modern threats, but also a catalyst for the evolution of military strategy and tactics, heralding a new era in the efficiency and effectiveness of defense operations.

## CONCLUSION

This research highlights the importance of UGVS implementation in enhancing Indonesia's defense capabilities. Taking into account UGVS applications that have been adopted in several developed countries, this study identifies the potential of UGVS in enhancing defense capabilities, faces technical challenges in the integration of UGVS into existing defense systems, and formulates strategies to overcome these challenges. It also evaluates the performance of UGVS in combat situations and its impact on defense operations. In terms of potential, UGVS offers risk mitigation for personnel and the ability to conduct operations in locations previously considered inaccessible or high-risk. This includes the implementation of artificial neural network-based attitude control systems and the utilization of composite materials such as FRP (Fiber Reinforced Polymer) to improve mobility and operational efficiency. In terms of technical challenges, the development of autonomous systems for UGVS requires a rigorous technical approach, including the development of advanced software and proper sensor integration. Interoperability and communication issues between components from different manufacturers are also a key focus.

Regarding effectiveness and efficiency, the UGVS demonstrates increased precision and speed of response in combat situations, reduces risks to military personnel, and enables wider and faster deployment. The integration of artificial intelligence systems and advanced sensors enables UGVS to identify, track and evaluate targets with high accuracy. Overall, this research confirms the need for the integration of UGVS technology in Indonesia's defense system to improve operational effectiveness and efficiency, both in military and non-military contexts.

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