

PT Dirgantara Indonesia's Strategy in Empowering Drones for a Robust Air Defense System

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Abstract

Indonesia, as the world's largest archipelagic nation with an airspace covering 5,193,252 km², faces significant challenges in maintaining national security and territorial sovereignty. This study examines PT Dirgantara Indonesia's (PTDI) strategic approach to empowering drone technology for robust air defense systems. Using qualitative methods with literature review and meta-analysis, this research analyzes PTDI's capabilities, opportunities, and challenges in drone development. The findings reveal that drone integration can enhance airspace surveillance effectiveness by up to 40% with lower operational costs compared to conventional manned aircraft. PTDI possesses strong technical expertise in aerospace engineering, advanced manufacturing facilities, and robust government support. However, challenges include dependency on imported technology components and cybersecurity vulnerabilities. The strategic framework emphasizes three pillars: technological innovation, research and development collaboration, and production capacity enhancement. Through partnerships with international aerospace companies and domestic research institutions, PTDI aims to develop multi-role drones tailored to Indonesia's unique geographical and operational requirements, ultimately strengthening national defense capabilities while promoting indigenous defense industry independence.

Keywords: *Drone Technology, Air Defense System, PT Dirgantara Indonesia, Defense Industry, Strategic Defense.*

INTRODUCTION

In the era of globalization and rapid technological advancement, national security has become a crucial aspect for every country, including Indonesia. As the world's largest archipelagic nation with an airspace area of 5,193,252 km² (Ministry of Defense of the Republic of Indonesia, 2015), Indonesia faces significant challenges in maintaining its sovereignty and territorial integrity, particularly against aerial threats. A strong and resilient air defense system is an urgent necessity considering Indonesia's strategic geographic position between two continents and two oceans, and its direct borders with ten neighboring countries. This condition makes Indonesia vulnerable to various forms of aerial security threats, ranging from airspace violations to potential air attacks from other nations.

Research conducted by Cordesman and Colley (2015) from the Center for Strategic and International Studies (CSIS) emphasizes that countries with complex geography like Indonesia require a multi-layered approach to their air defense systems. This study indicates that integrating drone technology into air defense systems can enhance operational flexibility and cost-effectiveness by up to 40% compared to conventional systems. These findings align with the analysis conducted by Indonesia's National Resilience Institute (Lemhannas) in 2023, highlighting the potential for a 40% increase in airspace surveillance effectiveness through drone integration, with lower operational costs than manned aircraft.

The development of global military technology has introduced an increasingly complex and diverse spectrum of aerial threats. According to a 2023 report by the Stockholm International Peace Research Institute (SIPRI), there has been a significant global increase in investments in air defense technologies, with a primary focus on the development of fifth-generation fighter jets,

integrated air defense systems, and the utilization of drones for various military missions. Modern aerial threats are no longer limited to conventional fighter jets but also include surveillance drones, cruise missiles, and even cyberattacks targeting air defense systems. In this context, Indonesia must possess an air defense system that is not only robust but also adaptive and responsive to the evolving threat landscape.

A comprehensive study by Gettinger (2019) from the Center for the Study of the Drone at Bard College analyzed the proliferation of military drone systems in over 100 countries. The research revealed that between 2009 and 2018, the number of countries with active military drones increased from 60 to 95, with significant improvements in capabilities and complexity. This finding underscores the urgency for Indonesia to develop competitive drone capabilities to keep pace with global advancements and ensure national security.

One of the technological innovations that has transformed the global air defense landscape is the use of drones or Unmanned Aerial Vehicles (UAVs). Drones have become an integral component of modern defense strategies, offering flexibility, cost-efficiency, and operational capabilities that are difficult to achieve with conventional aerial platforms. According to a study by Frost & Sullivan (2019), the global military drone market is projected to reach \$23.78 billion by 2027, with a compound annual growth rate (CAGR) of 12.7% during the 2022–2027 period. This growth is driven by the increased adoption of drones for Intelligence, Surveillance, and Reconnaissance (ISR) missions and the development of autonomous combat drones.

Research by Horowitz et al. (2016) from the University of Pennsylvania and Texas A&M University explored the impact of drone proliferation on international conflict dynamics. The study concluded that countries adopting drone technology tend to be more proactive in cross-border military operations, though they also face higher escalation risks. These findings stress the importance for Indonesia not only to develop drone capabilities but also to formulate clear doctrines and protocols for their use in national defense.

Advanced countries such as the United States, Israel, and Turkey have demonstrated success in integrating drones into their air defense systems. The United States, for example, has deployed the MQ-9 Reaper drone for reconnaissance and precision strike missions in various theaters of operation. A study by Davis et al. (2020) on the effectiveness of U.S. drone operations showed a significant increase in ISR capabilities and an 80% reduction in military personnel risk during high-risk missions.

Israel, with its Heron and Hermes drones, has significantly enhanced its ISR capabilities. Research by Dobbing and Cole (2014) from Drone Wars UK analyzed the critical role of Israeli drones in military operations and border surveillance, showing up to a 65% increase in operational efficiency compared to conventional methods. Meanwhile, Turkey has achieved drone technology independence with the development of the Bayraktar TB2, proven effective in various regional conflicts. An analysis by Kasapoglu (2020) from Turkey's EDAM Think Tank highlighted how Turkey's strategic investment in drone technology has shifted the balance of power in the Eastern Mediterranean and Caucasus regions.

These countries' successes serve as blueprints for developing nations like Indonesia to formulate drone empowerment strategies within their national air defense systems. However, it is essential to note that technology adoption must align with Indonesia's geopolitical context and specific needs. A comparative study by Franke (2014) from the European Council on Foreign Relations analyzed how different countries adapt drone technology according to their defense doctrines and security challenges, emphasizing the importance of tailored approaches based on national needs.

In the Indonesian context, empowering drone technology for air defense faces several significant challenges. First, dependence on foreign technology remains a primary issue. According to data from the Ministry of Defense (2023), over 70% of Indonesia's defense

equipment is still imported. Second, regulations concerning the military use of drones remain incomplete, creating a grey area in the operationalization and development of this technology. Third, research and development (R&D) infrastructure for drone technology in Indonesia is still limited, both in terms of human resources and facilities.

A study by Laksmana (2019) on the challenges of Indonesian military modernization identified that, aside from budget constraints, Indonesia also faces obstacles in technology transfer and the development of its domestic defense industry. Laksmana emphasized the need for a holistic approach that involves not only technology acquisition but also human resource development and the creation of a robust defense industrial ecosystem.

Despite these challenges, there are substantial opportunities that Indonesia can leverage. International collaboration in drone technology transfer presents a viable path forward. For example, the cooperation between PT Dirgantara Indonesia and Turkish Aerospace Industries (TAI) in developing a Medium Altitude Long Endurance (MALE) drone opens opportunities for Indonesia to accelerate its mastery of advanced drone technology. Furthermore, government investment in drone R&D, as outlined in the National Research Master Plan 2017–2045, serves as a vital catalyst for innovation in this sector.

Research by Bitzinger and Raska (2020), analyzing trends in international cooperation on defense technology development in Southeast Asia, highlighted the importance of partnerships focused on technology transfer and local capacity building—not merely equipment acquisition. They emphasized Indonesia’s potential to become a regional hub for military drone production, given its existing defense industry base and geopolitical position.

PT Dirgantara Indonesia (PTDI), as a state-owned enterprise operating in the aerospace sector, plays a strategic role in realizing the independence of the national defense industry. Since its establishment in 1976, PTDI has contributed significantly to the development of aviation and air defense technology in Indonesia. Notable PTDI projects include the development of the KF-X/IF-X fighter jet in collaboration with South Korea and the production of the CN-235 military transport aircraft, which has been exported to several countries.

A case study by Zuhdzul et al. (2022) analyzing PTDI’s role in the national defense industry ecosystem identified that although PTDI has achieved significant milestones, there is still a substantial gap in cutting-edge technology, particularly in unmanned systems. They recommended product diversification focusing on drone technology as a critical step to maintain PTDI’s relevance and competitiveness in the global market.

In the drone development domain, PTDI has taken progressive steps, such as launching the PUNA Wulung surveillance drone in 2014. However, given the rapid evolution of drone technology, a more comprehensive and ambitious strategy is required to position PTDI as a key player in the defense drone industry. PTDI has great potential in this regard, given its existing capabilities in aircraft design and manufacturing, as well as the international partnerships it has established over decades.

Rubin’s (2021) analysis of defense industries in developing countries emphasized the importance of focusing on niche capabilities to achieve competitive advantage. Rubin argued that countries like Indonesia, with emerging defense industries, should identify and concentrate resources on specific technological areas where they can excel. For PTDI, the development of multi-role drones tailored to Indonesia’s geographic and operational needs could become a promising niche market.

The urgency for PT Dirgantara Indonesia to design and implement a drone empowerment strategy integrated into the national air defense system is increasingly apparent. This is driven by several critical factors. First, escalating geopolitical tensions in the Indo-Pacific region, which could raise the risk of conflict. Second, the proliferation of drone technology among non-state actors, posing new threats to national security. Third, the need to optimize defense budgets through cost-effective yet efficient solutions to protect Indonesia’s vast airspace.

A study by Wu (2021) analyzing Indo-Pacific security dynamics and their implications for regional defense strategies emphasized the importance of asymmetric warfare capabilities, including drones, in creating a credible deterrent. Wu argued that countries like Indonesia, with budget constraints and vast territories, could gain significant strategic advantages through the effective adoption of drone technology.

According to the 2023 Lemhannas study, integrating drones into Indonesia's air defense system could enhance aerial surveillance effectiveness by up to 40%, with lower operational costs compared to manned aircraft. The study also highlighted the importance of developing multi-role drones capable of performing ISR missions while also having precision strike capabilities to strengthen deterrence against potential aggressors.

To realize the vision of national defense industry self-reliance, drone empowerment by PT Dirgantara Indonesia must align with the Ministry of Defense's Minimum Essential Force (MEF) initiative. MEF Phase III (2020–2024) emphasizes the development of indigenous defense technologies, including drones. Integrating drones into air defense systems will not only enhance the operational capabilities of the Indonesian Air Force but also stimulate the growth of the national defense industry ecosystem through multiplier effects in the supply chain and technology transfer.

PT Dirgantara Indonesia's drone empowerment strategy must consider several key aspects. First, focus on developing drones with specifications suited to Indonesia's geography and defense doctrine. This includes MALE drones for long-range maritime surveillance, tactical drones for border operations, and UCAVs (Unmanned Combat Aerial Vehicles) to enhance precision strike capabilities. Second, invest in critical technologies such as autonomous navigation systems, satellite communication, and artificial intelligence to improve drone operations across various scenarios.

The large-scale drone conflict between India and Pakistan in May 2025 demonstrated how UAVs can be used as a strategic pressure tool without direct risk to personnel-India responded by increasing UAV investment to ~\$470 million and accelerating domestic production (Ghoshal et al., 2025). This approach reflects the important role drones play in shaping diplomatic and defense positions. PT Dirgantara Indonesia's strategy for empowering drones in support of a robust air defense system represents a critical step in addressing modern national security challenges. Through a holistic approach involving technological innovation, industrial capacity building, and strategic partnerships, Indonesia has the opportunity to build an air defense system that not only protects national sovereignty but also advances defense industry self-reliance.

Successfully realizing this strategy will position Indonesia as a key player in drone technology in the region, while also strengthening its strategic posture in regional and global security dynamics. However, this success depends on long-term government commitment, adequate resource allocation, and close collaboration among PTDI, research institutions, and international partners. With the right approach, PTDI's drone empowerment efforts can not only enhance Indonesia's defense capabilities but also catalyze technological and industrial transformation across the country.

RESEARCH METHODS

This study employs a qualitative method using a literature review and meta-analysis approach, aiming to examine various relevant sources related to the research topic. Creswell (2016) states that a literature review serves to identify, analyze, and synthesize previous studies to comprehensively understand a phenomenon. Meanwhile, according to Glass (1976), meta-analysis is a technique that combines data from multiple related studies, providing a stronger

foundation for drawing valid conclusions. Through this approach, the study seeks to thoroughly explore the dynamics and strategies in the empowerment of drones within the air defense sector. The research utilizes a meta-analytical approach within the literature review to analyze the drone empowerment strategies implemented by PT Dirgantara Indonesia to strengthen the national air defense system. Using this method, the study gathers various studies, reports, and literature related to drone technology development in the defense industry at both national and global levels. Dearing's (2021) Theory of Technological Innovation is applied to understand the factors influencing the adoption of drones by PT Dirgantara Indonesia in air defense systems. Furthermore, Porter's (1998) Theory of Competitive Advantage explains how PT Dirgantara Indonesia can develop drones to create a competitive edge in the defense industry. In addition, Clausewitz's (1832) Military Strategy Theory provides an analytical framework to evaluate the role of drones in transforming the dynamics of modern aerial warfare. The application of Mintzberg's (1994) Corporate Strategy Theory is also relevant in explaining how PT Dirgantara Indonesia can design effective strategies to utilize drone technology as part of air defense innovation. This analysis explores both the potential and challenges faced by PT Dirgantara Indonesia in leveraging drones as a key component of Indonesia's air defense system.

RESULT AND DISCUSSION

Strengths and Opportunities of PT Dirgantara Indonesia

PT Dirgantara Indonesia (PTDI) has long served as the backbone of Indonesia's aerospace industry, with a rich history in aircraft design and manufacturing. The technical expertise accumulated over the years provides a strong foundation for PTDI to advance into a new era of drone technology. PTDI's team of engineers, with deep knowledge in aerodynamics, propulsion systems, and avionics, holds a significant advantage in transferring their expertise to the development of advanced drones. This expertise encompasses not only technical aspects but also a thorough understanding of Indonesia's unique operational requirements and geographical challenges, giving PTDI a competitive edge in designing drones tailored to local conditions.

PTDI's advanced and flexible manufacturing facilities are strategic assets in the company's efforts to expand its capabilities into the drone sector. Existing production lines can be quickly adapted to accommodate various types and sizes of drones, ranging from lightweight surveillance units to larger and more complex combat drones. This adaptability enables PTDI to respond swiftly to changing market and technological demands. Moreover, these facilities are equipped with state-of-the-art testing and quality control equipment, ensuring that every drone produced meets the highest safety and performance standards. Continued investment in modernizing these facilities reflects PTDI's commitment to innovation and quality.

PTDI's supply chain network, established over the years, is a valuable asset in developing drone capabilities. Strong relationships with both domestic and international suppliers allow PTDI to access specialized components and advanced materials required for the production of cutting-edge drones. This network not only ensures the availability of raw materials and critical components but also opens opportunities for collaboration in developing new technologies. PTDI has invested in sophisticated digital supply chain management systems, enabling better coordination with suppliers and inventory optimization, which in turn improves production efficiency and reduces costs.

PTDI's experience in international cooperation with global aerospace companies has opened the door to technology transfer and access to the latest innovations in the drone industry. These collaborations not only enhance PTDI's technical knowledge and capabilities but also position the company as a credible partner in international drone development projects. Through

these strategic partnerships, PTDI has participated in various joint research and development programs, enabling the company to stay at the forefront of drone technology. This experience has also helped PTDI understand international standards and regulations related to drones, which are essential for global market expansion.

Strong government support for PTDI as a strategic state-owned enterprise serves as an important catalyst in the company’s efforts to develop drone capabilities. This support includes not only funding for research and development but also policies that encourage the use of domestically produced goods for national defense. These policies create a conducive environment for PTDI to invest resources in drone technology development, with a more secure domestic defense market. The government has also facilitated collaboration between PTDI and leading research institutions and universities in Indonesia, creating a strong innovation ecosystem for drone technology development.

PTDI’s human resources are invaluable assets in its drone development efforts. The company’s engineers and technicians have expertise in various aerospace disciplines, which is crucial for the development of advanced drones. PTDI has implemented comprehensive employee development programs, including advanced training, exchange programs with international aerospace companies, and partnerships with higher education institutions. Investment in human resource development not only enhances the company’s technical capabilities but also fosters a strong culture of innovation within the organization.

Applying Porter’s Competitive Advantage Theory (1998), PTDI can leverage these strengths to create differentiation in its drone products. By focusing on innovations tailored to the specific needs of Indonesia’s air defense systems—supported by local expertise and a deep understanding of regional geographic and geopolitical conditions—PTDI gains a competitive advantage that is difficult for global competitors to replicate. PTDI can develop drones with unique characteristics suited to Indonesia’s operational environment, such as the ability to operate in tropical conditions, wide-range maritime patrol capabilities, and resilience to electronic interference.

Dearing’s (2021) Theory of Technological Innovation provides a framework for understanding the factors influencing PTDI’s adoption of drone technology. Factors such as relative advantage, compatibility with existing systems, complexity, trialability, and observability of outcomes are important considerations in PTDI’s drone development strategy. By understanding these factors, PTDI can design effective technology adoption strategies, ensuring that investments in drone technology not only produce advanced products but also enable successful adoption and integration into Indonesia’s air defense systems.

PT Dirgantara Indonesia’s strength in drone development is summarized in the SWOT Analysis in Table 1. PTDI possesses high technical expertise in aerospace, supported by advanced manufacturing facilities and a strong supply chain network. Government support further reinforces PTDI’s position in the industry. While challenges such as dependence on imported technology and limited large-scale production capacity exist, significant opportunities lie in international collaboration and product diversification to meet the evolving needs of national defense.

Table 1 SWOT Analysis of PT Dirgantara Indonesia in Drone Development

Strengths	Weaknesses
Technical expertise in aerospace	Limited specific experience in drone technology
Advanced manufacturing facilities	Dependence on certain imported components
Strong supply chain network	High development and production costs
Experience in international collaboration	Limited large-scale production capacity
Strong government support	

Highly skilled human resources	Bureaucratic processes that may hinder innovation Limited global marketing reach
Opportunities	Opportunities
Growth of the global drone market Increasing national defense needs Export potential to developing countries R&D collaboration with international institutions Diversification into the commercial drone sector Integration with modern air defense systems	Competition from international drone companies Rapid changes in drone technology Strict international regulations Regional geopolitical instability Fluctuations in national defense budgets Cybersecurity and data protection risks

Source: Compiled by the Researcher (2024)

Drone Development Strategy Analysis by PT Dirgantara Indonesia

PT Dirgantara Indonesia’s (PTDI) drone development strategy is a manifestation of the company’s vision to become a key player in national and regional air defense industries. This strategic approach is built upon three main pillars: technological innovation, research and development (R&D) collaboration, and production capacity enhancement. Each of these pillars is interconnected and mutually reinforcing, forming a holistic approach to PTDI’s drone capability development, in line with Mintzberg’s (1994) Corporate Strategy Theory.

Technological innovation lies at the core of PTDI’s strategy in drone development. The company focuses on developing technologies that not only follow global trends but are also tailored to the specific needs of Indonesia’s air defense. This includes R&D in lightweight composite materials to enhance efficiency and range, more efficient and environmentally friendly propulsion systems, and advanced sensor and avionics technologies to improve surveillance and navigation capabilities. PTDI is also investing in artificial intelligence (AI) and machine learning technologies to enhance drone autonomy and decision-making capabilities, in alignment with global trends in military drone development.

Research and development collaboration constitutes the second pillar of PTDI’s strategy. The company has formed strategic partnerships with leading universities, research institutions, and technology companies both domestically and internationally. These collaborations allow PTDI to access expertise and resources that may not be available internally, accelerate innovation processes, and share development risks. For instance, PTDI has initiated a joint project with the Bandung Institute of Technology (ITB) for the development of AI algorithms for autonomous drone navigation systems, as well as partnerships with European avionics companies to integrate advanced encrypted communication systems.

Enhancing production capacity is the third crucial pillar of PTDI’s strategy. The company has made significant investments in modernizing and expanding its production facilities to accommodate drone production lines. This includes the construction of dedicated hangars for drone assembly and testing, as well as the implementation of flexible manufacturing systems that can quickly adapt to various types and sizes of drones. PTDI has also adopted Industry 4.0 technologies, including automation, the Internet of Things (IoT), and big data analytics to improve production efficiency and quality.

The application of Dearing’s (2021) Theory of Technological Innovation provides a framework to understand the factors influencing PTDI’s adoption of drone technologies and their integration into Indonesia’s air defense system. Factors such as relative advantage, compatibility with existing systems, complexity, trialability, and observability of outcomes are key considerations in PTDI’s drone development strategy. For example, in terms of relative

advantage, PTDI focuses on developing drones that offer significant improvements in range, endurance, and payload capability compared to existing systems. Compatibility with existing air defense infrastructure is also a priority, ensuring that PTDI’s drones can be seamlessly integrated into current command and control systems.

Porter’s (1998) Competitive Advantage Theory provides the foundation for PTDI to develop a differentiation strategy in the defense drone industry. PTDI leverages its local advantages, including an in-depth understanding of Indonesia’s geographic and operational conditions, to develop drones uniquely suited for tropical and maritime environments. This includes features such as high humidity resistance, long-range operational capability for maritime patrol, and optimized cooling systems for tropical climates. This differentiation strategy not only enhances PTDI’s competitiveness in the domestic market but also opens export opportunities to countries with similar geographic conditions.

Clausewitz’s (1832) Military Strategy Theory offers an analytical framework to evaluate the role of drones in transforming the dynamics of modern aerial warfare. PTDI applies Clausewitzian principles such as the “fog of war” and “center of gravity” in its drone development. For example, PTDI’s surveillance drones are equipped with advanced sensors to reduce the fog of war, enhancing battlefield situational awareness for commanders. Meanwhile, combat drones are developed with a focus on precision capabilities to identify and strike at the enemy’s center of gravity, in line with modern military strategic principles.

The application of Mintzberg’s (1994) Corporate Strategy Theory is evident in PTDI’s approach that blends formal planning with the flexibility to respond to environmental changes. PTDI adopts an "emergent strategy" approach, allowing the company to adapt quickly to technological shifts and market demands while maintaining a long-term strategic direction. This is reflected in a flatter organizational structure and the formation of cross-functional project teams for drone development, enabling faster decision-making and more agile innovation.

Table 2 Strategy Recommendation Matrix for PTDI’s Drone Development

Strategic Aspect	Implementation	Related Theory
Technological Innovation	<ul style="list-style-type: none"> · Development of lightweight composite materials · Efficient propulsion systems · AI and machine learning for autonomous navigation · Advanced sensors and avionics 	Technology Innovation Theory (Dearing, 2021)
R&D Collaboration	<ul style="list-style-type: none"> · Collaboration with universities and research institutions · Partnerships with global technology companies · Joint projects for AI development and composite communication systems 	Competitive Advantage Theory (Porter, 1998)
Production Capacity Improvement	<ul style="list-style-type: none"> · Modernization of production facilities · Implementation of Industry 4.0 technologies · Smart manufacturing systems 	Corporate Strategy Theory (Mintzberg, 1994)
Military Adaptation	<ul style="list-style-type: none"> · Drone design tailored for tropical and maritime conditions · Integration with existing air defense systems · Focus on reducing the “fog of war” 	Military Strategy Theory (Clausewitz, 1832)

Source: Compiled by the Researcher (2024)

International research indicates that the global military drone industry is experiencing significant growth. According to a report by Frost & Sullivan (2019), the global military drone market is projected to reach a value of \$23.78 billion by 2027, with a compound annual growth

rate (CAGR) of 12.7% from 2019 to 2027. This growth is driven by increasing investments in unmanned technology by countries worldwide, as well as a paradigm shift in military doctrines that increasingly emphasize the importance of unmanned systems in modern operations.

In this context, PTDI's strategy to focus on the development of military drones aligns with global trends. However, a major challenge is the intense competition from well-established global players. Research by Gilli and Gilli (2019) in the *International Security* journal highlights that the barriers to entry in the advanced military drone industry are very high, mainly due to the technological complexity and the substantial investment required. Therefore, PTDI's strategy of collaborating with international partners and domestic research institutions becomes crucial.

PTDI's technological innovations in drone development align with findings from a study by Kasapoglu (2020), which emphasized the importance of integrating AI and machine learning technologies into military drone systems to enhance autonomy and operational effectiveness. PTDI has adopted this approach by making significant investments in the development of AI algorithms for autonomous navigation and decision-making.

PTDI's strategy to develop drones tailored to Indonesia's geographic conditions is supported by research from Alkire et al. (2016) at the RAND Corporation. Their study found that drones specifically designed for certain operational environments have significant advantages in terms of effectiveness and durability. This strengthens PTDI's approach of creating competitive advantages through specialization, in line with Porter's Competitive Advantage Theory.

In the area of research and development collaboration, PTDI has established strategic partnerships with various entities. One notable example is a joint project with the Bandung Institute of Technology (ITB) for the development of AI-based autonomous navigation systems. This project involves researchers from ITB's School of Electrical Engineering and Informatics, who specialize in artificial intelligence and robotics. The collaboration not only enables PTDI to access cutting-edge academic expertise but also contributes to the development of local talent in drone technology.

PTDI has also signed a memorandum of understanding with Thales, a French avionics company, for the development of secure and interference-resistant drone communication and control systems. This partnership includes technology transfer and training for PTDI engineers, in line with the company's strategy to enhance its internal capabilities in key military drone technologies.

In its effort to increase production capacity, PTDI has made substantial investments in modernizing its manufacturing facilities. The implementation of Industry 4.0 technologies, as recommended in a study by Spyridon (2023) on digital transformation in the defense industry, has enabled PTDI to improve production efficiency and flexibility. The newly implemented flexible manufacturing system allows the company to quickly switch between the production of various types of drones, enabling a more effective response to market demand fluctuations.

The application of Clausewitz's Military Strategy Theory in PTDI's drone development is clearly reflected in the design of its surveillance drones. These drones are equipped with advanced electro-optical and infrared sensors capable of operating in various weather and lighting conditions, helping reduce the "fog of war" during military operations. Additionally, the ability to integrate data from these drones into broader command and control systems enables faster and more accurate decision-making on the battlefield, in line with modern military strategy principles.

Integration of Drones into Indonesia's Air Defense System

The integration of drones into Indonesia's air defense system is a transformative step that requires a holistic and multidimensional approach. This process involves not only technological aspects but also changes in military doctrine, organizational structure, and operational procedures. From the perspective of Clausewitz's Military Strategy Theory, drone integration can be seen as an effort to reduce the "fog of war" and improve the ability to identify and target

the enemy's "center of gravity" more effectively. In the context of modern air defense, drones offer continuous surveillance capabilities, precision strike ability, and operational flexibility that are difficult to achieve with traditional platforms.

One key aspect of drone integration is interoperability with existing systems. Indonesia's current air defense system includes multiple elements such as ground-based radar, fighter aircraft, and surface-to-air missile systems. Drones must be able to operate harmoniously within this ecosystem, share data in real-time, and respond to commands from an integrated command and control center. Research by Clark et al. (2017) emphasizes the importance of open system architecture and standardized communication protocols to enable seamless integration. PT Dirgantara Indonesia (PTDI) has adopted this approach in its drone development, ensuring compatibility with NATO standards such as STANAG 4586 for unmanned system interoperability.

The implementation of Artificial Intelligence (AI) and Machine Learning (ML) technologies plays an integral role in drone integration into air defense systems. AI allows drones to perform real-time data analysis, identify potential threats, and even propose courses of action to human operators (Montasari, 2022). A study by Al-Suqri & Gillani (2022) highlights AI's potential to enhance decision-making speed and accuracy in military operations.

Another essential aspect of integration is the development of new doctrines and operational tactics. The unique capabilities of drones—such as long-term persistence and the ability to operate in high-risk environments without endangering personnel—require new approaches to mission planning and execution. Research by Cook (2015) shows that countries that have successfully integrated drones into their force structures have made significant revisions to their military doctrines. The Indonesian Air Force, in collaboration with PTDI, has established a special working group to develop drone operational doctrines that cover aspects such as Rules of Engagement (ROE) for autonomous drone operations and procedures for integrating drones into joint operations.

Geopolitical and strategic factors also play a significant role in drone integration into Indonesia's air defense. As the world's largest archipelagic nation with vast maritime territory, Indonesia needs effective long-range surveillance and patrol capabilities. Drones provide a cost-effective solution to this challenge. An analysis by Mazzeo (2021) indicates that the use of drones for maritime patrol can increase area coverage by up to 300% compared to traditional methods, with significantly lower operational costs. PTDI has responded to this need by developing Medium-Altitude Long-Endurance (MALE) drones specifically for maritime operations, equipped with surface-search radar and automatic identification systems for vessel detection and tracking.

Challenges and Opportunities in Empowering Drones for Defense

Empowering drones for defense presents a complex and multidimensional set of challenges and opportunities. One of the primary challenges is cybersecurity and resistance to electronic warfare. Drones that heavily rely on satellite navigation and wireless communication systems are vulnerable to cyberattacks, jamming, and spoofing. Research by Omolara et al. (2023) revealed that cyberattacks on military drone systems increased by 300% between 2015 and 2020. To address this, PT Dirgantara Indonesia (PTDI) has made major investments in the development of anti-jamming systems and advanced encryption. Collaboration with Israeli cybersecurity firm Check Point Software Technologies has resulted in an integrated cybersecurity suite capable of detecting and mitigating various types of cyber threats in real-time. However, the ever-evolving nature of cyber threats means that improving security must be a continuous process.

The second challenge lies in the complexity of integrating drones into existing air defense systems. Interoperability between drones and conventional platforms such as fighter aircraft and surface-to-air missile systems remains a significant issue. According to Bronk (2020), only 60%

of military drone systems are fully interoperable with existing command and control infrastructure. PTDI has adopted the NATO STANAG 4586 standard for unmanned systems interoperability, but full implementation still requires substantial time and investment. Collaboration with Thales Group in developing resilient data link systems is a vital step in addressing this challenge. However, full harmonization with legacy systems remains a complex and time-consuming task.

From a regulatory and policy perspective, the use of military drones faces significant legal and ethical challenges. The lack of clarity in international law regarding the use of armed drones—especially in asymmetric conflicts and cross-border operations—creates a complex legal gray area. A study by Boyle (2018) highlights the urgent need for a clear legal framework to govern military drone use. Indonesia, as a country committed to international legal norms, must proceed carefully in developing drone use doctrines that align with global standards. In developing its Unmanned Combat Aerial Vehicle (UCAV), PTDI has integrated an “ethical governor” — an AI system designed to ensure compliance with Rules of Engagement (ROE) and the laws of armed conflict in autonomous decision-making.

Operational challenges are also significant, particularly given Indonesia’s unique geographical context. As the world’s largest archipelagic state, Indonesia requires drones with long-range and high-endurance capabilities for effective maritime patrol. Frequent extreme weather conditions, such as tropical storms and high humidity, add to the complexity of drone design and operation. PTDI has responded to this challenge by developing MALE drones optimized for tropical conditions, equipped with de-icing systems and specialized anti-corrosion sealing. However, extensive testing and ongoing refinement are required to ensure reliability across diverse operational environments.

On the opportunity side, empowering drones opens the door to significant transformation in Indonesia’s air defense capabilities. Drones offer continuous surveillance and precision strike capabilities with far lower personnel risk than traditional platforms. An analysis by Kunertova (2019) shows that countries that have effectively integrated drones into their defense architecture experienced, on average, a 40% increase in threat detection capability and a 60% improvement in rapid response to incidents. For Indonesia, with its vast maritime domain, drones could dramatically enhance patrol and surveillance capacity, closing coverage gaps left by conventional radar systems.

Drone empowerment also presents opportunities for disruptive innovation in military strategy and tactics. Concepts like "swarm intelligence" and autonomous drone operations have the potential to fundamentally alter the nature of aerial warfare. PTDI, in collaboration with researchers from the Bandung Institute of Technology (ITB) and the Singapore University of Technology and Design, is developing a “drone swarm” concept capable of operating autonomously in large formations. If successful, this project could give Indonesia a significant advantage in future air defense scenarios. However, the development of such technologies also introduces new ethical and strategic challenges that must be carefully addressed.

Table 3 SWOT Analysis of Drone Empowerment for Indonesian Defense

Strengths	Weaknesses
Technical expertise in aerospace Strong government support Unique geographical conditions as a “natural laboratory” Strong collaboration with research institutions	Dependence on certain imported components Lack of experience in large-scale drone operations Limited supporting infrastructure Constraints in large-scale production capacity
Opportunities	Opportunities

Growth of the global military drone market Export potential to developing countries Technology spillover to the civilian sector Transformation of national air defense capabilities	Competition from well-established global drone manufacturers Risks of cyber security and electronic warfare Uncertainty in international regulations Advancements in anti-drone technologies
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Source: Compiled by Researcher (2024)

The empowerment of drones for defense brings with it a complex set of challenges and opportunities. While technical, operational, and regulatory challenges remain significant, the opportunities for transforming defense capabilities, driving economic growth, and fostering technological innovation are highly promising. Indonesia's success in navigating this landscape will depend on a balanced and strategic approach—one that combines technological innovation with thoughtful ethical and strategic considerations. PTDI, supported by the government and in collaboration with international partners and research institutions, is well-positioned to lead this effort. However, flexibility and adaptability will be essential, given the evolving nature of drone technology and the ever-changing geopolitical landscape.

CONCLUSION

This comprehensive analysis of PT Dirgantara Indonesia's strategy in empowering drones for a robust air defense system reveals both significant potential and substantial challenges in Indonesia's pursuit of defense technological independence. The study demonstrates that PTDI possesses critical foundational strengths, including advanced aerospace expertise, sophisticated manufacturing capabilities, and strong government support, which position the company favorably for drone development initiatives. The research findings indicate that PTDI's strategic approach, built on three main pillars—technological innovation, research and development collaboration, and production capacity enhancement—aligns effectively with established theoretical frameworks of Porter's Competitive Advantage Theory, Dearing's Technology Innovation Theory, Clausewitz's Military Strategy Theory, and Mintzberg's Corporate Strategy Theory. PTDI's unique position as Indonesia's premier aerospace company, combined with its deep understanding of local operational requirements and tropical maritime conditions, creates distinctive competitive advantages in developing drones specifically tailored for Indonesia's archipelagic geography.

However, the study also identifies significant challenges that must be addressed, including technological dependencies on imported components, increasing cybersecurity threats targeting unmanned systems, evolving international regulatory frameworks, and Indonesia's unique geographical complexities requiring sophisticated drone designs. Despite these challenges, the SWOT analyses reveal substantial opportunities for transformative impact on Indonesia's defense capabilities, with potential for 40% improvement in airspace surveillance effectiveness and 60% enhancement in rapid response capabilities. The projected growth of the global military drone market to \$23.78 billion by 2027 presents substantial opportunities for PTDI, particularly in developing specialized capabilities for tropical and maritime environments that position the company favorably for both domestic applications and export to countries with similar geographic conditions.

In conclusion, PT Dirgantara Indonesia's strategy for empowering drones in support of a robust air defense system represents both a critical national security imperative and a significant economic opportunity. While the challenges are substantial, the combination of PTDI's existing

capabilities, government support, strategic partnerships, and Indonesia's unique operational requirements creates a foundation for success that depends on sustained commitment, strategic resource allocation, and adaptive implementation approaches. The transformation of Indonesia's air defense capabilities through drone empowerment is not merely a technological undertaking but a comprehensive strategic initiative requiring coordinated efforts across multiple domains—from technological innovation and industrial capacity building to doctrinal development and international cooperation. PTDI's leadership in this effort, supported by robust analytical frameworks and strategic partnerships, positions Indonesia to achieve greater defense self-reliance while contributing to regional security stability in the increasingly complex Indo-Pacific strategic environment.

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