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Selection and Utilization Strategy of Unmanned Aerial Vehicles (UAVs) for Frigate-Class Warship Operations in the North Natuna Sea

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ABSTRACT

This study examines the selection and strategy for utilizing Unmanned Aerial Vehicles (UAVs) to increase the effectiveness of the operational tasks of the Republic of Indonesia Warship frigate Class in the North Natuna Sea, a strategic area facing complex maritime security dynamics and territorial disputes. Using a descriptive qualitative approach combined with the Analytical Hierarchy Process (AHP) method, this study evaluates various UAV alternatives based on relevant technical and operational criteria, such as endurance, range, operational capability, and compatibility with ship systems. The results of the analysis show that based on the results of the priority matrix analysis in the AHP process, the most suitable UAV to support the operations of the Frigate Class Warship in terms of capability and cost aspects is UAV II. Furthermore, SWOT analysis is used to formulate a strategy for utilizing UAVs, resulting in six strategies, namely: 1) Implementation of cost-effective UAV II for continuous ISR; 2) Mapping of disputed zones or areas in the North Natuna Sea with the help of UAV II; 3) Integrating UAV II with CMS for ASW; 4) Automating SAR/CBRN responses; 5) Integrating drones for real-time threat analysis in the North Natuna Sea; 6) Improving coordination between Fleet Command I, Warships and UAV II through Big Data analysis and data integration with other stakeholders. Theoretically, this study enriches the literature on multi-criteria decision-making in the context of maritime security and UAV technology and provides an evaluation model that can be adapted to various maritime military operations. Practically, this study provides a significant contribution to the development of Indonesia's maritime defense posture, especially in facing security challenges in the North Natuna Sea, and offers applicable recommendations for optimizing UAV technology in supporting the operations of the Frigate Class Warship.

1. Introduction.

Indonesia as an archipelagic country that has sovereignty over the region must continue to strive to improve security at the jurisdictional boundaries to overcome existing threats. The North Natuna Sea is the most strategic area due to the high environmental dynamics in these waters (Mustofa, 2022). This strategic sea location makes it a focal point for regional security dynamics, especially considering the overlapping territorial claims by various countries (Hadiwijaya, 2022). In recent years, tensions have increased in the North Natuna Sea due to overlapping territorial claims and resource exploration activities. Such disputes have led to occasional confrontations between Indonesian authorities and Chinese fishing vessels or coast guard vessels operating in these disputed waters (Suwarno et al., 2021). The North Natuna Sea has very important ecological and economic significance, as it supports marine ecosystems such as coral reefs, mangrove forests, and seagrass beds that are habitats for various species of economic value for local

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fisheries, but these ecosystems are threatened by overfishing, illegal practices, pollution, and the impacts of climate change so that the government and international organizations are trying to encourage sustainable management; On the other side, the huge potential of hydrocarbon resources beneath its seabed attracts the interest of multinational energy companies and plays an important role in meeting regional energy needs and the national economy, although its exploration often faces geopolitical and environmental challenges that require careful negotiation between stakeholders.

Figure 1: North Natuna Sea Map.

Source: Muhaimin (2018).

To improve Maritime Domain Awareness (MDA) and protect the sovereignty of the territory of the Republic of Indonesia, the Indonesian Navy is expected to develop a posture capable of implementing control (Mustofa, 2022). The Republic of Indonesia Warship (KRI) as part of the Integrated Fleet Weapons System (SSAT) has a central role in maintaining sovereignty in the waters of national jurisdiction (Gindarsah & Priamarizki, 2021). However, there are still violations of the law, especially in the North Natuna Sea, indicating that the implementation of operations carried out by warships, especially the Frigate Class Warship, is still not optimal.

To increase the effectiveness of these operations, the use of cutting-edge technology is very important. One innovation that has great potential for adoption is the Unmanned Aerial Vehicle (UAV). The development of UAV technology has undergone significant transformations since the early 20th century, starting from military use in World War I with early models such as the Kettering Bug which functioned as an automatic flying bomb. After World War II, rapid progress occurred during the Cold War, when the United States and the Soviet Union developed advanced UAVs for surveillance and reconnaissance without risk to pilots, such as the Ryan Firebee which could be remotely controlled and reused. These developments laid the foundation for modern UAV applications by increasing reliability and operational range (Utama & Anwar, 2021). Late 20th century The civil sector began exploring UAVs for tasks such as agricultural monitoring, environmental research, and infrastructure inspection (Barros et al., 2024).

Table 1: UAV categories are defined by UVS International.

Name Category	Mass [Kg]	*Range [Kg]*	*Flight altitude [m]*	*Endurance [hours]*
Micro	<5	<10	<250	1
Mini	<25/30/150	<10	150/250/300	<2
Close Range	25–150	10–30	3000	2–4
Medium Rage	50–250	30–70	3000	3–6
High Alt Long Endurance	>250	>70	>3000	>6

Source: Baros et al (2024).

The use of Unmanned Aerial Vehicles (UAVs) as supporting elements in the operations of the Frigate Class Warship is a strategic response to technological advances, especially in dealing with violations of the law in the North Natuna Sea area. The strategic use of UAVs increases the situational awareness of naval vessels, providing real-time data that is very important for the decision-making process (Norcia et al., 2023). UAVs have the advantage of expanding the scope of monitoring, providing real-time data, and increasing the effectiveness of maritime operations without posing a risk to the safety of the crew. However, the implementation of UAVs in the Indonesian Navy environment still faces obstacles, especially related to limited range and endurance. Currently, the Frigate Class Warship is not equipped with a UAV that can optimize the effectiveness of operational patterns.

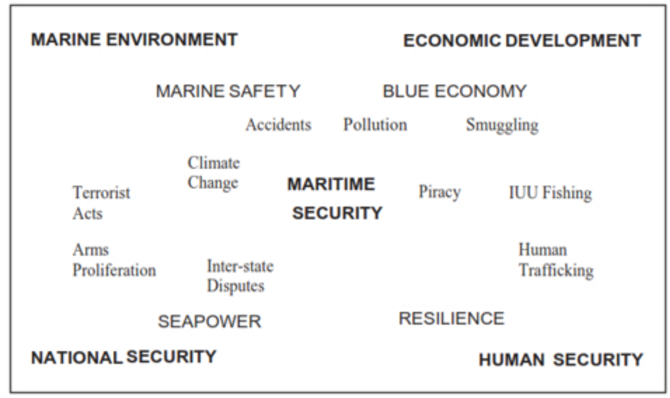
The limited effectiveness of the Frigate Class Warship operations in maintaining territorial sovereignty, especially due to the less than optimal utilization of cutting-edge technology such as UAVs, is a major concern that must be addressed immediately so that Indonesia can improve its Maritime Domain Awareness (MDA) and respond quickly to various maritime threats. The urgency of this research lies in the need to formulate a strategy for selecting and utilizing the right UAV, so that the Indonesian Navy can obtain real-time data, expand the scope of surveillance, and increase the effectiveness of operational decision-making without increasing the risk to the safety of the ship's crew. Therefore, this research is very important and urgent to be carried out considering the high complexity and dynamics of security threats in the North Natuna Sea, which is a strategic area with territorial disputes, large natural resource potential, and the intensity of law violations that are still high.

This study aims to provide an analysis of the selection and strategy of utilizing Unmanned Aerial Vehicles (UAV) to improve the capability of carrying out the operational tasks of Frigate Class Warship in the North Natuna Sea. This study is supported by the approach of maritime security theory and decision-making theory, the Analytical Hierarchy Process (AHP) method, and the SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis method, with a literature study approach and qualitative descriptive statistics. This study is expected to contribute to increasing the effectiveness of maritime surveillance and rapid response to security threats, by providing real-time data and broader monitoring capabilities on the utilization of UAVs in Frigate Class Warship operations in the North Natuna Sea. This approach is expected to be able to produce comprehensive and applicable recommendations for the Indonesian Navy in maximizing the utilization of UAVs to support Frigate

Class Warship operations in the North Natuna Sea.

This study provides theoretical contributions through the development of an integrative model that synergizes the Maritime Security Framework with the Multi-Criteria Decision Making (MCDM) approach based on the Analytical Hierarchy Process (AHP), especially by formulating 4 main UAV criteria clusters (technical, operational, geostrategic, and economic). Practically, this study provides concrete and applicable recommendations for the Indonesian Navy in optimizing the use of UAVs as a supporter of Frigate Class Warship operations to face geopolitical, environmental, and security challenges in the Indonesian maritime border area, especially in the North Natuna Sea.

Figure 2: Maritime security matrix.



Source: Buerger (2015).

2. Literature Review.

2.1. Maritime Security Theory.

Maritime security is one of the current buzzwords in international relations. Key actors in maritime policy, maritime governance, and international security have in the last decade begun to include maritime security in their mandates or reframe their work in such terms (Bueger, 2015). There are various definitions of maritime security, the form of which depends on the specific perspective taken. As an element of the broader concept of global security, maritime security has traditionally been associated with a state's military interests. Modern piracy, terrorism, fishing crimes, and maritime migrant smuggling are just some of the maritime insecurities that have made headlines over the last decade (Chapsos, 2016).

Maritime security encompasses a range of threats such as interstate disputes, terrorism, piracy, illegal trade, illegal fishing, environmental crimes, and maritime accidents and disasters. Traditional definitions that emphasize the absence of these threats have been criticized for under-prioritizing issues, ignoring the interrelationships between threats, and not explaining how to address them, leading to confusion about which threats should be prioritized (Bueger, 2015). In this context, maritime security has evolved from a primary focus on the security of transportation—such as shipping, ports, and sea lanes—to become an important part of international security and geopolitics, given that human interaction with the sea has long involved activities such as fishing and trade (Amirell, 2016).

Maritime Security connects various related concepts and can replace some of them by studying the meanings that actors hold through the relationships of these concepts, which can be visualized in a matrix such as the one in Figure 2. This matrix allows the analysis of the types of relationships that are built between maritime security and other concepts by various actors and identifies what is included or excluded in their understanding of maritime security.

2.2. Multi-Criteria Decision Making.

Multi-criteria Decision Making (MCDM) is a branch of operations research that deals with decision-making problems involving multiple criteria. This theory is important in situations where decisions are complex and involve conflicting objectives. MCDM provides a framework for evaluating, prioritizing, and choosing among alternatives based on multiple criteria. This theory has been widely applied in fields such as economics, engineering, environmental management, and public policy. It helps decision-makers make informed choices by considering all relevant factors and their consequences (Massam, 1988). The foundation of MCDM lies in the recognition that real-world decision-making often involves multiple conflicting objectives that cannot be easily reduced to a single criterion. MCDM provides a methodology for systematically evaluating these consequences and arriving at the most satisfactory decision. One of the key components of MCDM is the formulation of the decision problem. This involves identifying the objectives or criteria that are important to the decision-maker and organizing them into a coherent framework. The criteria may be quantitative or qualitative and may have varying degrees of importance or weight assigned to them. This process also involves identifying feasible alternatives that need to be evaluated against these criteria (Momeni et al., 2021).

Several methods have been developed in MCDM to aid in the decision-making process. Some popular techniques include Analytic Hierarchy Process (AHP), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), ELECTRE (Elimination Et Choice Translating Reality), and PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluations). Each method has its strengths and weaknesses depending on the nature of the decision problem and the preferences of the decision maker (Li et al., 2023). Analytic Hierarchy Process (AHP) is one of the most widely used MCDM methods due to its simplicity and effectiveness in handling both qualitative and quantitative data. AHP involves decomposing a complex decision problem into a hierarchy of simpler subproblems, which can then be analyzed independently. Decision-makers use pairwise comparisons to assign priorities among criteria and alternatives, resulting in rankings that reflect their overall preferences (Khan et al., 2021).

3. Method.

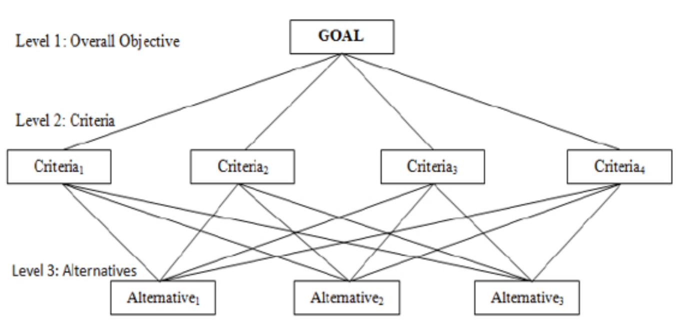
This study uses a qualitative descriptive statistical approach to gain a deeper understanding of the opinions and experiences of experts on the vulnerability of security strategies to threats and to produce a more informative and applicable analysis (Putra et al., 2023). In this study, the Analytical Hierarchy Process (AHP) method is used to help determine the best choice of Unmanned Aerial Vehicle (UAV) that will support the operations of the Frigate Class Warship in the North Natuna Sea by comparing various UAV alternatives based on several relevant criteria systematically and measurably, while the SWOT method is used to formulate a strategy for utilizing selected UAVs through an analysis of strengths, weaknesses, opportunities, and threats, so that the implementation of UAVs can run optimally and by the internal and external conditions faced by the Frigate Class Warship.

3.1. Analytical Hierarchy Process (AHP).

Analytical Hierarchy Process (AHP) describes complex multifactor or multi-criteria problems into a hierarchy, according to Saaty hierarchy is defined as a representation of a complex problem in a multi-level structure, where the first level is the objective, followed by the level of factors, criteria, sub-criteria and so on down to the last level of alternatives with a hierarchy a complex problem can be described in groups which are then arranged into a hierarchy as the problem will appear more systematically structured (Improta et al., 2018).

One of the main advantages of AHP that distinguishes it from other decision-making models is that there is no absolute consistency requirement. So that the existing problems can be felt and observed, but the completeness of the numerical data does not support modeling the problem quantitatively. In determining the weight of each criterion in AHP can be described as follows (Rahmawati et al., 2019):

Figure 3: Hierarchy Diagram in AHP.



Source: Saaty (1990).

Seven pillars that are used and must be considered in AHP modeling (Saaty & Vargas, 2013), such as:

a. Ratio scale is a comparison of two values (a/b) where the values a and b are of the same type (unit). Ratio scale is a set of ratios that are consistent in the same transformation (multiplication by a positive constant). A set of values (in the same units) can be standardized by normalizing so that units are no longer needed and the objects can be more easily distinguished from each other.
b. Pairwise comparison. Pairwise comparison is done to give relative weight between criteria and/or alternatives, so that the priority of the criteria and/or alternatives will be obtained. There are three approaches to ordering alternatives or criteria, namely relative, absolute, and benchmarking. The approach is used for critical general criteria. The absolute approach is used at the lower level of the hierarchy where there is usually detailed information that can be quantified from each criterion. In the benchmark approach, alternatives are compared with known reference alternatives, and then the alternatives are ordered according to the results of the comparison.
c. Conditions for sensitivity of eigenvectors The sensitivity of eigenvectors to changes in the criterion limits the number of elements in each comparison set. This requires homogeneity of the elements involved. The change must be by selecting a small element as a unit and asking how much it affects the larger elements.
d. Homogeneity and clustering. Clustering is used when the differences between elements are more than one degree, to gradually widen the fundamental scale, eventually enlarging the scale from 1 to 9 to infinity. This is especially true for relative measurements.
e. Synthesis. Synthesis is applied to the ratio scale to create a unidimensional scale to represent the overall outcome, using additional weighting.
f. Maintaining and reversing the order of weighting and ranking in the hierarchy is influenced by the addition or change of criteria or alternatives. Often there is a phenomenon of rank reversal, especially in relative measurements. Rank reversal is intrinsic to decision making as is the condition of maintaining the order.
g. Group considerations. Group considerations must be integrated carefully and mathematically. With AHP, it is possible to consider the experience, knowledge & strengths of the individuals involved.

Humans can instinctively estimate simple quantities through their senses. For this reason, quantitative scales of 1 to 9 are established to assess the comparative level of importance of one element to another.

The steps of the AHP method include:

a. Create a pairwise comparison matrix.

$$A = a_{jm} = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \cdots & 1 \end{bmatrix}$$

i, m = 1, 2, ... , n = related criteria index.

b. Create a criteria value matrix.
c. Create a Summation Matrix for Each Row.

d. Consistency Index (CI) and Consistency Ratio (CR) assessment.

$$CI = \frac{\lambda_{\max} - n}{n},$$

$$CR = \frac{CI}{RI}$$

N = Number of Elements,
RI = *Random Consistency Index*.

If the CR ratio is 0.1 (i.e. 10%), the matrix is said to be consistent and the decision W is accepted. On the contrary, a CR greater than that implies too many contradictions in the matrix. Anticipation for the latter situation is to review the matrix, and then revise the weights assigned by the vectors.

Table 2: Random Consistency Index Value.

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Source: Saaty (1990).

3.2. SWOT (Strength, Weakness, Opportunity, Threat).

SWOT analysis is a strategic planning tool used to identify and evaluate internal and external factors that can affect an organization's ability to achieve its goals (Gurl, 2017). This method is widely used in business strategy formulation, marketing, and project management. The acronym SWOT stands for Strengths, Weaknesses, Opportunities, and Threats. Each component of the SWOT framework provides a unique perspective on an organization's environment and helps in developing strategies that leverage strengths, mitigate weaknesses, exploit opportunities, and defend against threats.

The four main aspects of SWOT analysis (Susilo et al., 2019), include:

a. Strength Refers to the internal attributes or resources an organization possesses that gives it a competitive advantage over others. These can include tangible assets such as proprietary technology, a strong brand reputation, a skilled workforce, or financial resources.
   Intangible strengths may involve the organization's culture or leadership qualities. Identifying strengths is important because they form the foundation on which strategy is built. By understanding what an organization does well, it can focus its efforts on areas that have the greatest potential for success.
b. Weakness. These are internal factors that can hinder the organization's performance or limit its ability to achieve its goals. These could be outdated technology, lack of expertise in a particular area, poor location, or inefficient processes. Recognizing weaknesses is critical for organizations to proactively address them before they become significant problems. By recognizing these limitations, organizations can develop strategies to improve or offset their weaknesses.
c. Opportunity is an external factor that an organization can exploit to its advantage. This can arise from market trends, technological advances, changes in consumer preferences, or regulatory shifts. Opportunities provide a path for growth and expansion if identified and pursued effectively. Organizations must remain vigilant to recognize emerging opportunities early so they can act quickly to capitalize on them before competitors do.
d. Threats. Represent external challenges that could negatively impact an organization's performance or survival. These may include economic downturns, increased competition, regulatory changes, or disruptive technologies. Understanding threats is critical to risk management and strategic planning because it allows an organization to develop contingency plans and defensive strategies to protect itself from potential adverse impacts.

Integrating these four components into a cohesive analysis allows organizations to gain a comprehensive understanding of their strategic position within their industry or market environment. By systematically evaluating each element of a SWOT analysis, strengths and weaknesses are internal factors while opportunities and threats are external factors, organizations can develop appropriate strategies that align with their capabilities while effectively navigating external conditions (Uztürk & Büyüközkan, 2023).

SWOT analysis serves as a versatile tool that can be applied in a variety of sectors beyond business including healthcare management, educational planning, and non-profit strategy development among others due to its simplicity yet the deep insights it offers into the strategic decision-making process across a variety of contexts. By using SWOT analysis regularly throughout the strategic planning cycle; organizations not only increase their awareness of current realities but also better prepare themselves for future uncertainties thereby fostering resilience and adaptability amidst a changing environment (Susilo et al., 2020).

Table 3: SWOT Matrix.

Internal/External Factors	**Strength (S) (Maximum)**	**Weakness (W) (Minimum)**
Opportunities (O) (Maximum)	SO Strategy (Maximum-Maximum)	SO Strategy (Maximum-Maximum)
Threat (T) (Minimum)	ST Strategy (Maximum-Minimum)	WT Strategy (Minimum-Minimum)

Source: Susilo et al. (2019).

4. Results.

The analysis stage begins with the identification of criteria for determining the selection of UAVs obtained from literature studies and Small Group Discussions (SGD). Second, the UAV selection process uses the AHP method supported by a priority matrix from the aspects of Ability and Cost. Third, the planning of the UAV utilization strategy on Frigate Class Warship with a

SWOT analysis that begins with an analysis of internal factors (strengths and weaknesses) and external factors (opportunities and threats/constraints). The SWOT analysis is also supported by factor weighting from the AHP method, then determining the strategy used in utilizing UAVs using the QSPM Matrix, to identify quadrants in the strategy. All stages are carried out using a qualitative descriptive statistical analysis method approach.

4.1. Research Object.

4.1.1. Frigate Class Warship.

Frigate Class Warship is one type of frigate that has an average role and capability like other combat ships. The advantage of this type is that the procurement cost is relatively cheap. This type of ship is often manned by highly specialized naval combat units and usually functions to support other warships in their missions. Individual frigates can be equipped with, for example, submarine detectors, anti-aircraft weapons, or defense against surface ships. In terms of dimensions, the MRLF has a relatively smaller size of around 100 meters. Unlike other combat types that are over 100 meters in size. This is advantageous for the MRLF type because it reduces the possibility of the ship being detected due to radar reflection (allowing the development of stealth mode). In addition, with a size that is not too large, this type of ship can act like a patrol ship (Satriananda & Manfaat, 2015).

From a technical perspective, this type of ship has received a lot of praise. Among them are fast maneuverability, regular ship movements, and reliable speed. Meanwhile, from a weaponry perspective, the MRLF is no less complete than other combat ships. For example, the crew-class frigate has a maximum speed of 30 knots equipped with radar sensors and avionics made by Thales, France. In addition, this ship is equipped with one 76 mm cannon, two 30 mm caliber anti-aircraft guns, torpedoes, Thales Sensors Cutlass 22, Sea Wolf surface-to-air missiles, Exocet MM40 Block II missiles with a range of 180 km, and a hangar that can accommodate one Sikorsy S-70 Seahawk anti-submarine helicopter.

Figure 4: Frigate Class Warship.

Source: Authors.

4.1.2. UAV Alternatives.

As in developed countries, various UAV models are being developed for defense purposes. In this paper, three alternative UAVs have been identified to support the operations of the Frigate Class Warship, namely:

a. Camcopter S-100.

The Camcopter S-100 is a prime example of an unmanned aerial vehicle (UAV) that has been widely used for a variety of applications, from military to civilian. The Camcopter S-100 is characterized by its compact size and helicopter-like design, which allows it to take off and land vertically without the need for a runway. This feature makes it very versatile and suitable for operations in confined spaces or on ships. In a military context, the Camcopter S-100 serves as an invaluable asset for intelligence, surveillance, target acquisition, and reconnaissance (ISTAR) missions. Its ability to operate autonomously reduces the risk to human operators while providing real-time data critical to the decision-making process. The UAV's payload capacity allows it to carry advanced sensors such as electro-optical/infrared (EO/IR) cameras and radar systems that enhance situational awareness on the battlefield.

Figure 5: Camcopter S-100.

Source: Choi et al (2011).

b. Golden Eagle CR500.

NORINCO's Golden Eagle CR500 unmanned attack helicopter is the latest unmanned attack helicopter developed by China North Industries Corporation. In modern warfare, unmanned helicopters have very high utility value. This unmanned helicopter is small in size, with a takeoff weight of only a few hundred kilograms, but can carry two small missiles. Proportionally, it can carry more ammunition than a manned unmanned helicopter. Thanks to technological advances, it can also carry more ammunition. In particular, the fully automatic attack capability is not limited by the takeoff and landing location and can follow the troops.

Figure 6: Golden Eagle CR500.

Source: es.militarydrones.org.cn.

Figure 7: Sea Cavalry SD 40.

Source: Xiamen Han's Eagle Aviation Technology Co.,Ltd.

c. Sea Cavalry SD 40.

The Sea Cavalry SD 40 is a maritime unmanned aerial vehicle (UAV) system designed for a variety of naval applications, including reconnaissance, surveillance, and target acquisition. The UAV system represents a significant technological advancement in the field of autonomous maritime operations, offering enhanced capabilities for navies. The SD.40 features a robust airframe constructed from lightweight composite materials, providing durability without sacrificing performance. Its aerodynamic design allows for stable flight even in turbulent weather conditions, making it ideal for long-range missions over open waters.

One of the Sea Cavalry SD.40's key technological features is its advanced sensor suite, which includes high-resolution cameras, infrared sensors, and radar systems. These sensors enable the UAV to conduct detailed surveillance operations both day and night, providing real-time data to naval commanders. In reconnaissance missions, the SD.40 excels at gathering intelligence on enemy movements and positions without exposing human personnel to risk. Its ability to loiter over areas of interest for extended periods allows it to provide continuous situational awareness.

4.2. *Identification of UAV Selection Criteria.*

At this step, a two-level hierarchical model is created that is generated from the Ability and Cost aspects and reflected in the UAV system, as shown in Figure 8. The model categorizes the main types of UAV capability determination factors: a) Payload capacity; b) Speed; c) Altitude; d) Endurance; e) Remote Control Range; f) Impact on ship operations; g) Weight. Table 4 shows the hierarchical model for UAVs with cost criteria.

Table 4: Identification of ability criteria.

Criteria	Description	Source
Payload capacity	Payload capacity is the maximum amount of weight that can be carried by the UAV. The fact that the UAV's payload weight is too heavy to be carried will shorten the battery life and cause possible damage to the UAV's carrier parts. The UAV can carry while in flight, including sensors, cameras, or other equipment about the payload capacity.	Nuh Keleş (2024)
Speed	Increasing the maximum speed will increase the efficiency and effectiveness of the UAV, speed is a characteristic that directly affects the efficiency of the war system. The maximum speed can vary based on the aircraft engine power, and the speed value can be requested at the highest, lowest, or average value by different functions.	Nuh Keleş (2024)
Altitude	Maximum altitude is the highest altitude level of the UAV in effective flight. The increase in the radius where the UAV can take pictures and perform its tasks without being affected and unknown to the air defense system during its tasks indicates the altitude at which the UAV can fly.	Nuh Keleş (2024)
Endurance	Maximum endurance refers to the length of time a UAV spends during its flight, that is, the maximum time spent with available fuel from takeoff to landing.	Nuh Keleş (2024)
Remote Control Range	Remote control range, as an important parameter, is known as the maximum distance that the UAV can travel in the remote control area. This is a parameter that can be affected by various variables depending on the remote control range, remote control signal, battery level, flight altitude, possible magnetic activity in the flight environment, natural or artificial terrain forms.	Nuh Keleş (2024)
Impact on ship operations	To what extent does the launching system affect the normal operational effectiveness of the ship	Norcia et al (2023)
Weight	System weight.	Norcia et al (2023)

Source: Authors.

Table 5: Identification of cost criteria.

Criteria	Description	Source
Purchase cost	Initial financial outlay required to acquire a UAV, including costs associated with acquiring the vehicle itself, the necessary equipment, and any associated technology or software required for its operation	Ardil (2023)
Operating cost	Costs incurred during the actual operation of the UAV. These costs include fuel or energy consumption (for electric drones), labor costs for operators and support staff.	Ardil (2023)
Maintenance cost	Maintenance costs include all costs associated with keeping the UAV in optimal working condition.	Ardil (2023)
Spare parts cost	Spare parts costs refer to expenses for replacement components required to repair or upgrade the UAV.	Ardil (2023)
Depreciation cost	Depreciation costs are the reduction in value of the UAV over time due to use, technological obsolescence, or market changes.	Ardil (2023)

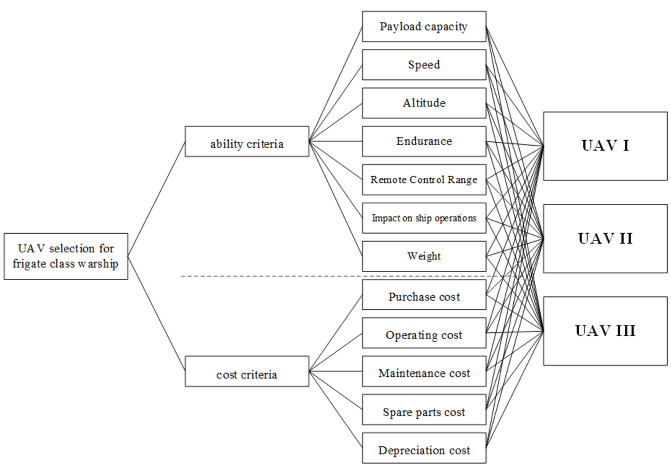
Source: Authors.

4.3. *Selection Analysis with AHP method.*

In multi-criteria structures, the weights of the criteria can be determined by various methods. The analytical hierarchy process (AHP) method, which is widely used in the literature and has found consistency in determining the weights of the criteria, is used to find the importance/priority of the criteria. In AHP, complex and mixed decision problems are decomposed into simple decision problems involving a decision hierarchy.

Measurable and immeasurable goals can be included in the same hierarchy. After the decomposition is complete, the AHP method requires the creation of a master ranking for the goals and alternatives under each goal. This step can be simplified by using pairwise comparisons, and assigning numerical scores to subjective judgments. The pairwise comparisons are then converted into master rankings. This creates an order of alternatives that is consistent with the decision-maker's perception. This process involves quantifying subjective judgments that can bring a large amount of noise to the model. Since the comparison of criteria is in a hierarchy, the numerical values in the scale indicate the priority of the relationship between the items. In AHP, the decision maker evaluates each decision alternative according to his criteria and scores points with a numerical scale. The questionnaire was prepared using the Saaty 1?9 scale and the criteria used in this study were compared in opposite pairwise directions ((Keleş, 2024).

Figure 8: Hierarchical Model of UAV Selection for Frigate Class Warship Operations.



Source: Authors.

Table 6: The results of the weighting values of the ability criteria.

Code	Factors	EXP 1	EXP 2	EXP 3	EXP 4	EXP 5	EXP 6	AVERAGE
C1	Payload capacity	0.167	0.140	0.136	0.116	0.210	0.229	0.166
C2	Speed	0.154	0.174	0.187	0.148	0.159	0.188	0.168
C3	Altitude	0.151	0.172	0.142	0.226	0.097	0.089	0.146
C4	Endurance	0.097	0.128	0.161	0.094	0.210	0.083	0.129
C5	Remote Control Range	0.152	0.157	0.144	0.098	0.093	0.160	0.134
C6	Impact on ship operations	0.093	0.099	0.151	0.194	0.116	0.154	0.135
C7	Weight	0.187	0.131	0.079	0.124	0.115	0.097	0.122

Source: Authors.

Table 7: The results of the capability cost weighting value.

Code	Factors	EXP 1	EXP 2	EXP 3	EXP 4	EXP 5	EXP 6	AVERAGE
C8	Purchase Cost	0.199	0.214	0.174	0.194	0.279	0.254	0.219
C9	Operating Costs	0.256	0.208	0.226	0.223	0.188	0.230	0.222
C10	Maintenance Cost	0.177	0.232	0.220	0.291	0.109	0.138	0.195
C11	Spare Parts Cost	0.148	0.144	0.198	0.146	0.279	0.118	0.172
C12	Depreciation Cost	0.220	0.202	0.182	0.146	0.145	0.260	0.193

Source: Authors.

Table 8: Comparison results of alternatives from capability criteria.

Alternatives		C1	C2	C3	C4	C5	C6	C7
Criteria		0.166	0.168	0.146	0.129	0.134	0.135	0.122
A1	UAV I	0.241	0.312	0.211	0.261	0.198	0.198	0.198
A2	UAV II	0.548	0.490	0.548	0.411	0.490	0.490	0.490
A3	UAV III	0.211	0.198	0.241	0.328	0.312	0.312	0.312
Alternatives		C1	C2	C3	C4	C5	C6	C7
Criteria		0.166	0.168	0.146	0.129	0.134	0.135	0.122
A1	UAV I	0.040	0.053	0.031	0.034	0.026	0.027	0.024
A2	UAV II	0.091	0.083	0.080	0.053	0.066	0.066	0.060
A3	UAV III	0.035	0.033	0.035	0.042	0.042	0.042	0.038
Alternatives							Weight	Rank
A1	UAV I						0.234	3
A2	UAV II						0.498	1
A3	UAV III						0.267	2

Source: Authors.

Table 9: Comparison Results of alternatives from cost criteria.

Alternatives		C8	C9	C10	C11	C12
Criteria		0.219	0.222	0.195	0.172	0.193
A1	UAV I	0.312	0.334	0.164	0.320	0.239
A2	UAV II	0.490	0.525	0.539	0.557	0.623
A3	UAV III	0.198	0.142	0.297	0.123	0.137
Alternatives		C8	C9	C10	C11	C12
Criteria		0.219	0.222	0.195	0.172	0.193
A1	UAV I	0.068	0.074	0.032	0.055	0.046
A2	UAV II	0.107	0.116	0.105	0.096	0.120
A3	UAV III	0.043	0.031	0.058	0.021	0.026
Alternatives				Weight	Rank	
A1	UAV I			0.275	2	
A2	UAV II			0.545	1	
A3	UAV III			0.180	3	

Source: Authors.

In this study, the determination of the selected UAV from the AHP method is supported by a priority matrix. The selection of Unmanned Aerial Vehicles (UAVs) to support the operation of Frigate-class Warship involves a strategic process that considers various factors. The Frigate-class Warship, which consists of the MRLF in the Indonesian Navy, requires UAVs that can improve its maritime surveillance, reconnaissance, and tactical capabilities. A priority matrix is often used to systematically assess potential UAV options based on criteria such as range, endurance, payload capacity, sensor capabilities, interoperability with existing systems, and cost-effectiveness.

The priority matrix helps decision - makers consider these operational contexts with technology specifications to select the UAVs that offer optimal performance under expected conditions. In addition, interoperability with other naval assets is an important factor; thus, UAVs equipped with compatible communication systems are prioritized to ensure smooth data sharing and coordination during joint operations. Ultimately, using a comprehensive priority matrix approach can make the right decisions that increase the effectiveness of the capabilities and costs of using UAVs on Frigate Class Warship.

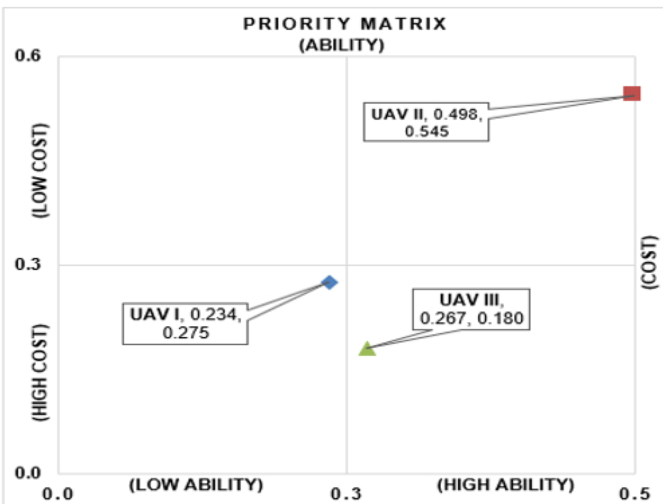
Based on the results of the priority matrix analysis, the most suitable UAV to support the operation of the Frigate-class Warship in terms of capability and cost is UAV II. UAV II emerged as the most appropriate choice because of its sophisticated ca-

Table 10: The weighted values of capabilities and costs from the AHP analysis.

	ALTERNATIVES	WEIGHT	
		ABILITY (X)	COST (Y)
A1	UAV I	0.234	0.275
A2	UAV II	0.498	0.545
A3	UAV III	0.267	0.180

Source: Authors.

Figure 9: Priority matrix in UAV selection.



Source: Authors.

pabilities that are in line with the operational requirements of the Frigate-class Warship.

4.4. Planning the UAV-Utilization Strategy Using SWOT Analysis.

4.4.1. Internal-Factor Analysis.

Internal Factor Analysis SWOT (Strengths, Weaknesses, Opportunities, Threats) for Unmanned Aerial Vehicle (UAV) utilization in naval operations involves a detailed examination of the intrinsic attributes that may influence the strategic deployment and effectiveness of UAVs in a maritime context. Strengths in this analysis often highlight the advanced technological capabilities inherent in UAV systems. Conversely, weaknesses identified through internal factor analysis may include limitations related to the UAV's endurance and payload capacity, which may limit its operational range and functionality in certain scenarios. Internal factor identification of strengths and weaknesses in this manuscript was obtained from literature review and Small Group Discussion which were then analyzed using weighting and Likert scale scoring.

Table 11: Analysis of internal factors of UAV utilization strategy on Frigate-class Warship.

Internal Factors			
Strengths (S)		Weaknesses (W)	
(S1)	High Economic Efficiency	(W1)	High Cost Of Procurement
(S2)	Mobility	(W2)	Need For Constant Monitoring
(S3)	Ease Of Control Accuracy	(W3)	Short Flight Time
(S4)	High Efficiency Performance	(W4)	Need For Permission To Use
(S5)	Environmental Cleanliness Of Flights	(W5)	Considerable Investment
(S6)	Life-Saving Capabilities	(W6)	Flight Time Limitations
(S7)	Reduction of Human Error	(W7)	Weather Dependence
(S8)	Adaptability		

Source: Authors.

Table 12: Pairwise comparison results of strength factors.

Code	Factor	EXP 1	EXP 2	EXP 3	EXP 4	EXP 5	EXP 6	AVERAGE
S1	High Economic Efficiency	0.126	0.122	0.140	0.116	0.207	0.215	0.154
S2	Mobility	0.200	0.151	0.153	0.152	0.146	0.158	0.160
S2	Ease Of Control Accuracy	0.128	0.158	0.140	0.154	0.107	0.111	0.133
S4	High Efficiency Performance	0.092	0.123	0.137	0.087	0.170	0.088	0.116
S5	Environmental Cleanliness Of Flights	0.129	0.135	0.121	0.090	0.093	0.118	0.114
S6	Life-Saving Capabilities	0.079	0.100	0.137	0.167	0.108	0.125	0.119
S7	Reduction of Human Error	0.161	0.125	0.073	0.143	0.095	0.100	0.116
S8	Adaptability	0.086	0.086	0.098	0.091	0.075	0.084	0.087

Source: Authors.

Table 13: Strength factor questionnaire results.

Code	Factor	EXP 1	EXP 2	EXP 3	EXP 4	EXP 5	EXP 6	AVERAGE
S1	High Economic Efficiency	4	4	3	5	4	5	4.167
S2	Mobility	5	3	4	5	5	4	4.333
S2	Ease Of Control Accuracy	4	4	5	4	4	5	4.333
S4	High Efficiency Performance	5	3	4	5	5	4	4.333
S5	Environmental Cleanliness Of Flights	4	3	5	5	4	4	4.167
S6	Life-Saving Capabilities	5	4	4	5	4	3	4.167
S7	Reduction of Human Error	5	5	4	4	5	4	4.500
S8	Adaptability	4	3	5	5	5	4	4.333

Source: Authors.

Table 14: Pairwise comparison results of weakness factors.

Code	Factor	EXP 1	EXP 2	EXP 3	EXP 4	EXP 5	EXP 6	AVERAGE
W1	High Cost Of Procurement	0.165	0.157	0.136	0.116	0.210	0.229	0.169
W2	Need For Constant Monitoring	0.167	0.185	0.187	0.148	0.159	0.188	0.172
W3	Short Flight Time	0.162	0.158	0.142	0.226	0.097	0.089	0.145
W4	Need For Permission To Use	0.097	0.139	0.161	0.094	0.210	0.083	0.131
W5	Considerable Investment	0.151	0.155	0.144	0.098	0.093	0.160	0.134
W6	Flight Time Limitations	0.073	0.079	0.151	0.194	0.116	0.154	0.128
W7	Weather Dependence	0.185	0.127	0.079	0.124	0.115	0.097	0.121

Source: Authors.

Table 15: Weakness factor questionnaire results.

Code	Factor	EXP 1	EXP 2	EXP 3	EXP 4	EXP 5	EXP 6	AVERAGE
W1	High Cost Of Procurement	4	4	4	4	4	5	4.167
W2	Need For Constant Monitoring	5	4	5	3	4	5	4.333
W3	Short Flight Time	4	3	3	4	4	5	3.833
W4	Need For Permission To Use	2	4	5	5	5	5	4.333
W5	Considerable Investment	3	3	4	4	5	4	3.833
W6	Flight Time Limitations	4	4	4	3	4	4	3.833
W7	Weather Dependence	3	4	5	5	4	4	4.167

Source: Authors.

4.4.2. External-Factor Analysis.

The SWOT (Strengths, Weaknesses, Opportunities, Threats) external factor analysis for the utilization of Unmanned Aerial Vehicles (UAVs) in Indonesian Navy operations involves a comprehensive examination of the opportunities and threats that exist in the external environment. Opportunities for the utilization of UAVs in naval operations are abundant due to technological advancements and strategic military needs. The global trend towards modernization of military forces also presents an opportunity for navies to adopt UAV technology as part of their strategic arsenal, which is in line with broader defense modernization initiatives.

In contrast, threats in the external environment must be carefully considered when strategizing the use of UAVs in naval operations. International regulatory and legal challenges governing the use of airspace pose potential barriers to widespread UAV deployment. Geopolitical tensions can further complicate the operational landscape, as states may impose restrictions or engage in cyber warfare tactics targeting UAV systems. Therefore, while there are significant opportunities to enhance naval operations through UAVs, these must be balanced against potential threats to ensure effective strategy formulation and implementation.

Table 16: External factor analysis of UAV utilization strategy on Frigate-class Warship.

External Factors	
Opportunities (O)	**Threats/Challenges (T)**
(O1) Operational monitoring from a height of tens and hundreds of meters (O2) Area Identification (O3) Measurement with high accuracy relief and GPS connection (O4) Maritime Digitization and Automation	(T1) High repair or replacement costs (T2) Complexity of control in certain situations (T3) limitations in the use of additional devices due to the geometric dimensions of the UAV (T4) Influence of Regulation

Source: Authors.

Table 17: Pairwise comparison results of probability factors.

Code	Factor	EXP 1	EXP 2	EXP 3	EXP 4	EXP 5	EXP 6	AVERAGE
O1	Operational Monitoring	0.128	0.137	0.131	0.243	0.329	0.394	0.227
O2	Area Identification	0.389	0.419	0.220	0.243	0.200	0.239	0.285
O3	Measurement	0.257	0.248	0.168	0.340	0.142	0.197	0.225
O4	Maritime Digitization and Automation	0.226	0.195	0.481	0.174	0.329	0.169	0.262

Source: Authors.

Table 18: Opportunity factor questionnaire results.

Code	Factor	EXP 1	EXP 2	EXP 3	EXP 4	EXP 5	EXP 6	AVERAGE
O1	Operational Monitoring	5	5	5	4	4	2	4.167
O2	Area Identification	4	4	4	5	4	4	4.167
O3	Measurement	5	5	5	4	5	2	4.333
O4	Maritime Digitization and Automation	5	5	4	4	4	4	4.333

Source: Authors.

Table 19: Results of pairwise comparison of threat/constraint factors.

Code	Factor	EXP 1	EXP 2	EXP 3	EXP 4	EXP 5	EXP 6	AVERAGE
T1	Repair costs	0.409	0.335	0.392	0.342	0.329	0.387	0.366
T2	Control complexity	0.265	0.136	0.279	0.288	0.206	0.275	0.242
T3	Limitations on use of additional devices	0.110	0.242	0.165	0.206	0.177	0.140	0.173
T4	Regulatory impacts	0.215	0.287	0.165	0.165	0.287	0.198	0.219

Source: Authors.

Table 20: Threat/constraint factor questionnaire results.

Code	Factor	EXP 1	EXP 2	EXP 3	EXP 4	EXP 5	EXP 6	AVERAGE
T1	Repair costs	4	5	2	4	3	4	3.667
T2	Control complexity	4	4	3	4	4	4	3.833
T3	Limitations on use of additional devices	4	5	2	4	4	4	3.833
T4	Regulatory impacts	5	5	2	4	4	5	4.167

Source: Authors.

4.4.3. QSPM Matrix Strategy Determination.

The final stage of the strategy analysis is the selection of an appropriate strategy that can be implemented to utilize UAVs in supporting the operation of the Frigate-class Warship, which is carried out using the QSPM analysis tool. Alternative strategies are obtained from the SWOT matrix where the matrix produces several alternative strategies through internal and external factors. The results of the analysis show that the highest value in the matrix is the progressive (maximum-maximum) strategy alternative, namely maximizing existing strengths to capture as many opportunities as possible. In this study, with the four opportunities available, it is hoped that they can be utilized by using maximum strength.

Table 21: Internal factor assessment analysis.

	INTERNAL FACTORS	WEIGHT	SCORE	VALUE
STRENGTH				
S1	High Economic Efficiency	0.154	4.167	0.642
S2	Mobility	0.160	4.333	0.693
S3	Ease Of Control Accuracy	0.133	4.333	0.576
S4	High Efficiency Performance	0.116	4.333	0.504
S5	Environmental Cleanliness Of Flights	0.114	4.167	0.476
S6	Life-Saving Capabilities	0.119	4.167	0.497
S7	Reduction of Human Error	0.116	4.500	0.523
S8	Adaptability	0.087	4.333	0.376
		1.000		4.288
WEAKNESS				
W1	High Cost Of Procurement	0.169	4.167	0.704
W2	Need For Constant Monitoring	0.172	4.333	0.747
W3	Short Flight Time	0.145	3.833	0.557
W4	Need For Permission To Use	0.131	4.333	0.566
W5	Considerable Investment	0.134	3.833	0.512
W6	Flight Time Limitations	0.128	3.833	0.490
W7	Weather Dependence	0.121	4.167	0.505
		1.000		4.082

Source: Authors.

Based on the SWOT analysis, the chosen strategy is the SO strategy, which is to maximize strengths to gain as many opportunities as possible. The SO strategy, which stands for Strengths-Opportunities, involves utilizing internal strengths to take advantage of external opportunities. In the context of a Frigate-class Warship, one of its main strengths is its advanced technological capabilities and strategic position in naval operations. UAVs provide significant advantages because of their ability to conduct surveillance, reconnaissance, and intelligence-gathering missions without risking human lives. This strength is in line with the opportunities presented by the increasing challenges of maritime security and the need to increase sit-

Table 22: External factor assessment analysis.

	EXTERNAL FACTORS	WEIGHT	SCORE	VALUE
OPPORTUNITY				
O1	operational monitoring	0.227	4.167	0.946
O2	area identification	0.285	4.167	1.188
O3	measurement	0.225	4.333	0.977
O4	Maritime Digitization and Automation	0.262	4.333	1.137
		1.000		4.248
THREATS/CONSTRAINTS				
T1	repair costs	0.366	3.667	1.341
T2	control complexity	0.242	3.833	0.926
T3	limitations on use of additional devices	0.173	3.833	0.664
T4	Regulatory Impact	0.219	4.167	0.914
		1.000		3.846

Source: Authors.

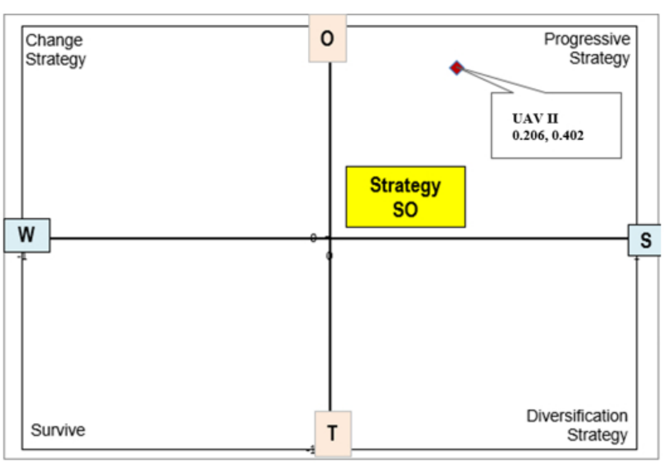
Table 23: Quadrant analysis results.

S	W	Quadrant	Axis
4.288	4.082	0.206	X
O	**T**	**Quadrant**	**Axis**
4.248	3.846	0.402	Y

Source: Authors.

uational awareness in vast ocean areas. By deploying UAVs, Frigate-class Warship can maximize its operational efficiency and effectiveness in monitoring maritime activities, thereby ensuring better protection of national waters and assets.

Figure 10: Determining the QSPM matrix strategy in quadrants.



Source: Authors.

Based on the results of the SWOT analysis, six strategies were obtained, namely:

a. Implementation of cost-effective UAVs for sustainable ISR (relationship between S1; O1)
b. Mapping of disputed zones or areas in the North Natuna Sea with the help of UAVs (relationship between S2; S3; O2)

Table 24: UAV utilization strategy to support the operations of the Frigate-class Warship in the North Natuna Sea.

	(O1) Operational monitoring from a height of tens and hundreds of meters (O2) Area Identification (O3) Measurement with high accuracy relief and GPS connection (O4) Maritime Digitization and Automation
(S1) High Economic Efficiency (S2) Mobility (S3) Ease Of Control Accuracy (S4) High Efficiency Performance (S5) Environmental Cleanliness Of Flights (S6) Life-Saving Capabilities (S7) Reduction of Human Error (S8) Adaptability	1) Implementation of cost-effective UAVs for sustainable ISR (S1;O1) 2) Mapping of disputed zones or areas in the North Natuna Sea with the help of UAVs (S2;S3;O2) 3) Integrating UAVs with CMS for ASW (S4;S8;O3) 4) Automating SAR/CBRN responses (S6;S5;O4) 5) Integrating drones for real-time threat analysis in the North Natuna Sea (S7;O1;O2) 6) Improving coordination between Fleet Command, Warship and UAVs through Big Data analysis and data integration with other stakeholders (S8;O4)

Source: Authors.

c. Integrating UAVs with CMS for ASW (relationship between S4; S8; O3)
d. Automating SAR/CBRN responses (relationship between S6; S5; O4)
e. Integrating drones for real-time threat analysis in the North Natuna Sea (relationship between (S7; O1; O2)
f. Improving coordination between Fleet Command, Warship, and UAVs through Big Data analysis and data integration with other stakeholders (relationship between S8; O4).

5. Discussion.

In this discussion, the determination of the selected UAV from the AHP method is supported by a priority matrix. The selection of Unmanned Aerial Vehicles (UAVs) to support the operations of the Frigate-class Warship involves a strategic process that considers various factors. The Frigate-class Warship, which consists of MRLF in the Indonesian Navy, requires a UAV that can improve its maritime surveillance, reconnaissance, and tactical capabilities. Based on the results of the priority matrix analysis, the most suitable UAV to support the operations of Frigate-class Warship in terms of capability and cost is the UAV II. The UAV II emerged as the most appropriate choice because of its advanced capabilities that are in line with the operational requirements of Frigate-class Warship. These ships, known for their versatility in maritime operations, require a UAV that can improve surveillance, reconnaissance, and intelligence-gathering capabilities while remaining within budget constraints.

The UAV II stands out in terms of capabilities due to its advanced technology and design features tailored for the maritime environment. It is equipped with high-resolution cameras and sensors that provide real-time data transmission, which is essential for effective decision-making during naval operations. Its endurance and range allow it to cover vast sea areas without frequent refueling or maintenance stops, making it ideal for long-term missions common to naval deployments. In addition, the compact size and ease of deployment of the naval platform make it highly compatible with the operational dynamics of the

Frigate-class Warship. The integration of these advanced technological features ensures that the UAV II can significantly enhance situational awareness and tactical superiority at sea.

Cost-effectiveness is another important factor that makes the UAV II stand out. Despite offering state-of-the-art technology, its price remains competitive compared to other UAVs with similar capabilities. This balance between cost and performance ensures that navies can deploy multiple units without exceeding budget constraints, thereby maximizing operational coverage and readiness. Furthermore, its low maintenance requirements reduce long-term operational costs, thus providing a sustainable solution for ongoing maritime surveillance needs. The combination of these factors—advanced capabilities at a reasonable cost—makes the UAV II an optimal choice to support the complex operational demands of the Frigate-class Warship.

The strategy of utilizing UAV (Unmanned Aerial Vehicle) UAV II in supporting the operation of Frigate-class Warship is a multifaceted approach that improves maritime surveillance, reconnaissance, and operational efficiency. The Frigate-class Warship is a modern multi-role frigate equipped with sophisticated weapons and systems designed for various naval operations, including anti-aircraft warfare, anti-submarine warfare, and surface warfare. Based on the results of the SWOT analysis, six strategies were obtained, namely:

a. Cost-effective application of Intelligence, Surveillance, and Reconnaissance (ISR).
   Integration with the Frigate-class Warship enables extended surveillance capabilities beyond line of sight, allowing these vessels to effectively monitor vast areas of ocean. The cost-effectiveness of these UAVs stems from their relatively low operational costs compared to manned aircraft, as well as their ability to operate autonomously for extended periods without requiring significant human intervention. The use of such advanced technology is in line with sustainable ISR practices by reducing the carbon footprint associated with traditional surveillance methods and increasing the efficiency of resource allocation. In addition, the deployment of UAVs such as the UAV II supports Indonesia's strategic interest in safeguarding its territorial waters from illegal activities and potential threats, thereby contributing to regional stability and security.
b. Mapping of disputed zones or areas in the North Natuna Sea with the help of UAV II.
   The deployment of UAV II, an advanced unmanned aerial vehicle equipped with high-resolution imaging and real-time data transmission capabilities, supports the operations of Indonesia's Frigate-class Warship by providing comprehensive aerial reconnaissance. The UAV enhances situational awareness by providing accurate geospatial data and imagery that is critical for navigation, monitoring foreign vessel activity, and enforcing maritime sovereignty. The integration of UAV technology with naval operations enables greater reach and operational efficiency in patrolling vast maritime areas. These technological advancements are critical in asserting national jurisdiction over disputed waters while ensuring compliance with international maritime law.
c. Integrating UAV II with Combat Management System (CMS) for Anti Submarine Warfare (ASW).
   By linking these UAVs to the CMS, which acts as the central nervous system of naval operations, it enables seamless data integration and processing. This integration facilitates rapid decision-making by providing comprehensive maritime domain awareness, enabling the detection, classification, and tracking of potential underwater threats such as submarines. The CMS processes inputs from multiple sensors on the UAV and the vessel itself to create a unified operational picture, thereby enhancing threat assessment and response strategies. This capability is critical in strategic areas such as the North Natuna Sea, where geopolitical tensions require robust maritime security measures. The synergy between UAV and CMS technologies not only increases the tactical reach of the Frigate-class Warship but also ensures they are well - equipped to maintain sovereignty and security in disputed waters.
d. Automation of SAR/CBRN response.
   The UAV II is equipped with advanced sensors and communication systems that enable it to perform autonomous reconnaissance, surveillance, and data collection tasks that are essential for SAR missions. Its ability to autonomously detect and analyze CBRN threats enhances the operational readiness of the Frigate-class Warship by providing real-time situational awareness and threat assessment. The automation features of the UAV allow it to operate efficiently in complex maritime environments, reducing human exposure to risk while increasing mission effectiveness. The integration of such technologies into naval operations represents a significant advancement in military strategy, leveraging artificial intelligence and machine learning algorithms to optimize decision-making processes during critical missions.
e. Integration of drones for real-time threat analysis in the North Natuna Sea.
   The UAV II's ability to provide high-resolution imagery and real-time data feeds allows naval commanders aboard the Frigate - class Warship to make informed decisions quickly. This capability is critical to identifying potential threats such as unauthorized vessels or illegal activities, allowing countermeasures to be taken. Furthermore, the drone's endurance and range complement naval assets by extending their surveillance reach beyond line of sight, providing comprehensive situational awareness that is essential for effective maritime operations.
f. Improving coordination between Fleet Command, warships, and UAV II through Big Data analysis and data integration with other stakeholders.
   By integrating these data streams with other stakeholders such as intelligence agencies, naval logistics, and regional security partners, comprehensive situational awareness can be achieved. This enhanced awareness enables

more informed decision-making processes regarding threat assessment, resource allocation, and mission planning. The use of Big Data technologies facilitates predictive analytics that can anticipate potential threats or logistics challenges before they arise, thereby optimizing fleet readiness and response times. Additionally, this integrated approach supports interoperability among multiple technology platforms and improves communication channels between command centers and deployed units, ensuring that all parties have access to the most current operational picture.

6. Implications.

Theoretically, this study provides an important contribution to the development of maritime security theory by integrating Unmanned Aerial Vehicle (UAV) technology into the Maritime Domain Awareness (MDA) framework. Theoretically, this study enriches the literature on multi-criteria decision - making (MCDM), especially the application of the Analytical Hierarchy Process (AHP) method and SWOT analysis in the context of maritime defense. This approach emphasizes the importance of systematic and comprehensive evaluation in selecting the right technology based on technical, operational, and strategic criteria. In addition, this study strengthens the understanding that the integration of UAV technology can expand the scope of surveillance and improve maritime security responses more effectively, thus enriching contemporary maritime security theory that emphasizes synergy between technology and operational strategy.

In practice, the results of this study provide concrete recommendations for the Indonesian Navy in optimizing the use of UAVs to support the operations of the Frigate-class Warship in the North Natuna Sea. By selecting the right UAV based on the criteria that have been analyzed, warships can increase the effectiveness of water area surveillance, accelerate detection and response to threats, and reduce risks for operational personnel. The UAV utilization strategy resulting from the SWOT analysis also helps in identifying opportunities for technology development and mitigating obstacles such as limited range and durability of UAVs. The implementation of this strategy is expected to significantly increase Indonesia's maritime sovereignty and security, especially in the strategic and conflict-prone North Natuna Sea area.

Conclusions.

The use of Unmanned Aerial Vehicles (UAV) as support in the implementation of operations held by Frigate-class Warship is a positive step in responding to technological advances to deal with violations of the law that occur, especially in the North Natuna Sea. This manuscript aims to provide an analysis of the selection of Unmanned Aerial Vehicles (UAV) to Improve the Implementation Capability of Frigate-class Warship Operational Tasks in the North Natuna Sea.

Based on the results of the AHP analysis, it was found that Based on the results of the priority matrix analysis, the most suitable UAV to support the operation of the Frigate-class Warship in terms of capability and cost is the UAV II. The UAV II emerged as the most appropriate choice because of its advanced capabilities that are in line with the operational requirements of the Frigate-class Warship. The UAV II stands out in terms of capability due to its advanced technology and design features that are tailored to the maritime environment. This UAV is equipped with high-resolution cameras and sensors that provide real-time data transmission, which is essential for effective decision-making during naval operations. Its endurance and range allow it to cover vast sea areas without frequent refueling or maintenance stops, making it ideal for long-term missions that are common in naval deployments. In addition, its compact size and ease of deployment of the naval platform make it highly compatible with the operational dynamics of the Frigate-class Warship. The integration of these advanced technological features ensures that the UAV II can significantly improve situational awareness and tactical superiority at sea.

Based on the SWOT analysis, the chosen strategy is the SO strategy, which is maximizing strengths to gain as many opportunities as possible. The SO strategy, which stands for Strengths-Opportunities, involves utilizing internal strengths to take advantage of external opportunities. In the context of Frigate - class Warship, one of its main strengths is its advanced technological capabilities and strategic position in naval operations. Based on the results of the SWOT analysis, six strategies were obtained, namely a) Implementation of cost-effective UAV II for continuous ISR; b) Mapping of disputed zones or areas in the North Natuna Sea with the help of UAV II; c) Integrating UAV II with CMS for ASW; d) Automation of SAR/CBRN responses; e) Combining drones for real-time threat analysis in the North Natuna Sea; f) Improving coordination between Fleet Command, Warship and UAV II through Big Data analysis and data integration with other stakeholders.

Based on the results of the analysis that has been carried out, the decision that can be taken is to utilize UAVs in the Frigate-class Warship operations in the North Natuna Sea using UAV2. UAV II provides significant advantages because of its ability to carry out surveillance, reconnaissance, and intelligence - gathering missions without risking human lives. This condition is in line with the opportunities presented by the increasing challenges of maritime security and the need to increase situational awareness in the vast ocean area.

Future Research.

There are several limitations in this study. First, this study is descriptive and does not involve direct testing or operational simulation of UAVs on the Frigate-class Warship, so it cannot empirically measure the effectiveness of UAV utilization strategies in real conditions in the North Natuna Sea. Second, the limitations of currently available UAV technology, such as range and battery life, also limit the recommendations that can be given. Therefore, further research with a quantitative approach and field testing is needed to strengthen the validity and practical application of the results of this study.

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References.

Amirell, S. E. (2016). Global maritime security studies: The rise of a geopolitical area of policy and research. Security Journal, 29(2), 276–289. https://doi.org/10.1057/sj.2013.26.

Ardil, C. (2023). Standard Fuzzy Sets for Aircraft Selection using Multiple Criteria Decision Making Analysis. International Journal of Computer and Information Engineering, 17(4), 299–307. https://orcid.org/0000-0003-2457-7261.

Barros, J., Henriques, J., Reis, J., Rosado, D. P., & Melão, N. (2024). Unmanned Aerial Systems: A Systematic Literature Review. Lecture Notes in Networks and Systems, 932 LNNS(February), 82–93. https://doi.org/10.1007/978-3-031-54235-0_8.

Bueger, C. (2015). What is maritime security? Marine Policy, 53, 159–164. https://doi.org/10.1016/j.marpol.2014.12.005.

Chapsos, I. (2016). Is maritime security a traditional security challenge? Advanced Sciences and Technologies for Security Applications, 59–78. https://doi.org/10.1007/978-3-319-27914-5_4.

Choi, K., Lee, J., & Lee, I. (2011). A uav multi-sensor rapid mapping system for disaster management. Gi4DM 2011 - GeoInformation for Disaster Management.

Gindarsah, I., & Priamarizki, A. (2021). Explaining Indonesia's Under-balancing: The Case of the Modernisation of the Air Force and the Navy. Journal of Asian Security and International Affairs, 8(3), 391–412. https://doi.org/10.1177/23477970211039645.

Gurl, E. (2017). SWOT analysis: A theoretical review.

Hadiwijaya, B. (2022). Strategi Pertahanan Maritim Di Laut Natuna Utara Dalam Rangka Mewujudkan Indonesia Sebagai Poros Maritim Dunia. NUSANTARA: Jurnal Ilmu Pengetahuan Sosial, 9(2), 418–429.

I Nengah, P., Amarulla, O., & April Kukuh, S. (2023). A hybrid AHP-TOPSIS for risk analysis in maritime cybersecurity based on 3D models I. Decision Science Letters, 12(2023), 759–772. https://doi.org/10.5267/dsl.2023.6.005.

Improta, G., Russo, M. A., Triassi, M., Converso, G., Murino, T., & Santillo, L. C. (2018). Use of the AHP methodology in system dynamics: Modelling and simulation for health technology assessments to determine the correct prosthesis choice for hernia diseases. Mathematical Biosciences, 299(February), 19–27. https://doi.org/10.1016/j.mbs.2018.03.004.

Keleş, N. (2024). A comparative evaluation of multi-criteria decision-making framework for armed unmanned aerial vehicle. International Journal of Intelligent Unmanned Systems, 12(4), 433–453. https://doi.org/10.1108/IJIUS-03-2023-0026.

Khan, S. A. R., Yu, Z., Golpira, H., Sharif, A., & Mardani, A. (2021). A state-of-the-art review and meta-analysis on sustainable supply chain management: Future research directions. Journal of Cleaner Production, 278, 123357. https://doi.org/10.1016/j.jclepro.2020.123357.

Li, X., Peng, Y., Guo, Y., Wang, W., & Song, X. (2023). An integrated simulation and AHP-entropy-based NR-TOPSIS method for automated container terminal layout planning. Expert Systems with Applications, 225(May 2022), 120197. https://doi.org/10.1016/j.eswa.2023.120197.

Massam, B. H. (1988). Multi-Criteria Decision Making (MCDM) techniques in planning. Progress in Planning, 30 (PART 1), 1–84. https://doi.org/10.1016/0305-9006(88)90012-8.

Momeni, M. A., Kumar, S., Jain, V., Mostofi, A., & ... (2021). A Perspective on Improving the Multicriteria Decision-Making Environment. IEEE Engineering .... https://ieeexplore.ieee.org/abstract/document/9323033/.

Muhaimin, R. (2018). Kebijakan Sekuritisasi dan Persepsi Ancaman di Laut Natuna Utara. Jurnal POLITICA, 9(Mei), 17–37. https://jurnal.dpr.go.id/index.php/politica/article/view/-1237.

Mustofa, A. Z. (2022). Indonesia's Strategy and Diplomacy in the South China Sea Conflict. Jurnal Pertahanan, 8(3), 414–425.

Norcia, N., Braidotti, L., Bertagna, S., Bucci, V., & Marino, A. (2023). Launching Systems for Unmanned Vehicles Onboard Naval Vessels. 2023 IEEE Electric Ship Technologies Symposium, ESTS 2023, 174–182. https://doi.org/10.1109/ESTS56571.2023.10220483.

Rahmawati, F., Nisaa', C., Syarif, R. I., & Nusantara, H. A. (2019). The Impact of Aircraft Spare Parts Import Duty Exemption on the MRO Industry's Competitiveness and Its Services Export. 3rd International Conference on Trade, 98(Icot), 200–205. https://doi.org/10.2991/icot-19.2019.42.

Saaty, T. L. (1990). How to make a decision: The analytic hierarchy process. European Journal of Operational Research, 48(1), 9–26. https://doi.org/10.1016/0377-2217(90)90057-I.

Saaty, T. L., & Vargas, L. G. (2013). Decision Making with the Analytic Network Process. Springer Science and Business Media.Satriananda, A. J., & Manfaat, I. D. (2015). Studi Pengembangan Desain Kapal Frigate Jenis MRLF Sebagai Infrastruktur Pertahanan Laut Di Indonesia Khususnya Wilayah Perairan Natuna [Institut Technology Sepuluh Nopember]. In ITS. http://repository.its.ac.id/70902/.

Susilo, A. K., Ciptomulyono, U., Putra, I. N., Ahmadi, & Suharyo, O. S. (2019). Navy development strategy to encounter threat of national maritime security using SWOT-fuzzy multi criteria decision making (F-MCDM). Journal of Maritime Research, 16(1), 3–16.

Susilo, A. K., Putra, I. N., Ahmadi, & Suharyo, O. S. (2020). Analysis of national maritime security strategy as an effect of regional development using SWOT, fuzzy multi criteria decision making (FMCDM) and borda. International Journal of Operations and Quantitative Management, 25(3), 153–174.

Suwarno, P., Sumantri, S. H., & Bahar, F. (2021). Rekonstruksi Keamanan Maritim Indonesia Dalam Rangka Mewujudkan Ketahanan Wilayah (Studi Di Kabupaten Natuna Periode Tahun 2019-2020). Jurnal Ketahanan Nasional, 27(1), 65–89.

Utama, A. B., & Anwar, S. (2021). History of The Use of Unmanned Aerial Vehicle (Uav) in The Modern War and The Preparation of The Indonesian Military. Jurnal Pertahanan & Bela Negara Universitas Pertahanan RI, Volume 11(3), 167–181.

Uztürk, D., & Büyüközkan, G. (2023). Strategic Analysis for Advancing Smart Agriculture with the Analytic SWOT/PESTLE Framework: A Case for Turkey. Agriculture (Switzerland), 13(12). https://doi.org/10.3390/agriculture13122275.