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Analysis of Warship Operational Readiness Toward Fifth-Generation Warfare

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ABSTRACT

Fifth-generation warfare is a continuation of fourth-generation warfare, namely warfare involving state actors against non-state actors. What is different in fourth-generation warfare is the involvement of terrorist groups who are enemies of the state in carrying out criminal activities. The fifth generation of warfare is marked by the emergence of Cyberwarfare and Information Warfare. Based on the research results, starting with the AHP method, it is known that the level of material readiness (0.493) is the criterion with the most important weight, followed by ship operational skills (0.368) and the level of personnel training (0.138). Furthermore, aircraft performance (0.176) is the most important sub-criterion besides eight other sub-criteria, namely joint training with foreign naval forces (0.165), logistics availability (0.156), integrated TNI-AL and TNI training (0.105), maintenance skills (0.104), advanced training (0.081), maintenance history (0.074), operating experience (0.070), and L1-L2 glagaspur training (0.065). At the stage of determining the best alternative using the TOPSIS method, the following results were obtained, namely: KRI B (0.880) is the KRI with the highest score at the maximum readiness level, likewise, KRI A (0.839) is also at the maximum readiness level, followed by KRI C (0.787) and KRI D (0.761) both at the medium readiness level. This research provides a real picture of the current operational readiness conditions of the KRI, especially the KRI SIGMA Class in fifth-generation warfare in supporting the duties of the Indonesian Navy.

1. Introduction.

Fifth-generation warfare has arrived and is irreversibly changing the character and nature of human conflict. This confronts the United States with a strategic dilemma that continues to develop, namely not only handling the war against terror, but also developing a strategy that not only looks at military readiness in facing wars in the past, but also includes the perspective of national readiness in facing a spectrum of conflicts in the future. There are four important elements of war, namely: new areas of conflict, changes in the nature of the enemy, changes in objectives, and changes inforces, to build a typology of generational wars and conflicts that inform the characteristics of fifth-generation warfare. The resulting model yields two results: First, it shows how recent events such as the rise of computer hackers, the 2001 anthrax and ricin attacks of 2003–2004, the 2004 Madrid bombings, and the rise of Al-Qaeda exhibit characteristics of fifth-generation warfare. Second, it illustrates how these events are unique indicators of a future in which non-state entities are increasingly able to fight as equals with nation-states (Reed, 2008).

In recent years, the Indonesian Navy (Tentara Nasional Indonesia Angkatan Laut) has made headlines when they purchased new submarines, tested Yakhont supersonic anti-ship missiles, and a whole host of other advanced platforms. Is Indonesia preparing to become a regional naval power on par with India, China, and Australia? Therefore, repairing these new ships (and extending their life cycles) was a large part of the naval power development plan in the late 1990s. One of the main priorities of the navy's leadership in the early 2000s

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was to acquire new ships to replace previous ones and add new submarines and strategic missile systems to increase the navy's defense capabilities. The four SIGMA corvettes arrived quite quickly: KRI Diponegoro July 2007), KRI Hasanuddin January 2008), KRI Sultan Iskandar Muda (December 2008), and KRI Frans Kaisiepo. Indonesia's cooperation with Damen also continued with the purchase of a new frigate. Acquiring a new fleet of frigates is a priority. However, the navy's aging ships, especially the Van Speijk class, have been given service life extensions to operate beyond 2020 (Laksmana, 2014).

Therefore, based on the above background and the current situation of strategic environmental developments, especially in maritime defense, research is deemed necessary regarding how to analyze the operational readiness of the KRI in supporting the duties of the Indonesian Navy if faced with fifth-generation warfare. What factors influence the operational readiness of the KRI, how do they influence the level of operational readiness of the KRI, and what is the sensitivity analysis in the operational readiness of the KRI. This research aims to determine the current level of operational readiness of the KRI when faced with the era of fifth-generation warfare by using operations management theory, readiness level theory, and fifth-generation warfare theory. The method approach used in this research is the Multi-criteria Decision Making method. The object studied in this research is the KRI SIGMA class corvette (Haryoko et al., 2020).

This research aims to identify what criteria influence the operational readiness of the KRI, determine the level of operational readiness of the KRI, and analyze sensitivity in the level of operational readiness of the KRI. This research uses qualitative descriptive statistical methods (Wahidmurni, 2017) AHP and TOPSIS approach techniques to identify and analyze KRI operational readiness. Based on recommendations (Finley et al., 2021), researchers used five levels of KRI operational readiness parameters. AHP–TOPSIS is also used to provide weights and comparisons of threat values based on nine criteria supporting KRI operational readiness.

This research is important because the output can be used as input and advice for the leadership of the Indonesian Navy in making the right decisions regarding KRI operations by knowing the level of readiness of the KRI operations to carry out the task of maintaining the sovereignty of the maritime territory of the Unitary State of the Republic of Indonesia (NKRI), especially to face generational warfare. So in the future, it is hoped that the Indonesian Navy will be able to adapt to changing patterns and developments in eras or generations of warfare which are quite dynamic from time to time. Several contributions were made through this research.

This research provides several contributions related to understanding and implementing operations management theory, readiness level theory, and fifth-generation warfare theory and enriching scientific principles related to the use of AHP and TOPSIS. Second, this research provides benefits for practitioners by providing positive output for the 2020-2024 TNI Strategic Plan; and also provides positive input to the Head of Work Units for building capabilities, both personnel and materials.

This research consists of several parts. The first part relates to the background matters of the research. The second part explains the literature review of factors influencing KRI operational readiness. The third section explains the methodology which consists of research design and conceptual framework. The fourth section explains the results and discussion, including validation of influencing factors using the Content Validity Index (CVI), pairwise comparisons of criteria and sub-criteria and their weighting using AHP, and determining the best alternative using TOPSIS. The fifth section is the research conclusion, implications, limitations, and future research.

2. Literature Review.

2.1. Operational Management.

Operations management relates to the management of organizational activities that produce goods and/or provide services needed by its customers (Radnor and Barnes, 2017). In his interesting article on the evolution of operations management from the 16th century to the 21st century, Sprague (2015) has discussed developments such as scientific management (Taylor's era), factory management (An extension of the Taylor's era), industrial management (in the 1930s), and production management (World War II and after). The field of study currently called operations management is the latest reincarnation of previous fields. It has been observed that the main research in operations management is oriented towards micro (isolated) issues focusing on technical aspects (equipment), but there has been a gradual increase in macro (more complex) issues and human-related aspects (Filippini, 2018).

As operations management has developed over the years, the decision-making process in operations management has also become more complex. As per Radnor and Barnes (2017), decision-making was oriented towards a single criterion of cost minimization (i.e., producing as efficiently as possible) in the early days, whereas newer approaches require consideration of multiple criteria such as quality, flexibility, timeliness, service delivery, and innovation. This requires the use of Multi-Criteria Decision Making (MCDM) methods to make effective decisions that meet all relevant requirements. (Subramanian & Ramanathan, 2012).

2.2. Readiness Level.

Achieving and maintaining the highest level of operational readiness or Operation Readiness Level (ORL) is the backbone of a strong and effective armed force, a main component of national security. One of the main components of the military, the navy plays an important role in ensuring the prosperity and peace of the nation and must be able to maintain the operational readiness level (ORL) at the highest point. The level of readiness of a warship consists of 3 main branches, namely: the level of personnel (crew) training; ship operating skills; and material readiness level (MRL) (Kocaman, 2009).

In a mechanism we are trying to optimize here, a ship periodically (e.g., once a week) applies a routine thorough check of the reliability and operability of its material systems and assigns credit values within a certain range to the material systems. After adding up the credits for each major system to obtain an overall score for each major system, they send regular reports to their direct headquarters at regular intervals in a specified format unless otherwise noted. This readiness monitoring ensures the condition of platform and system materials prior to deployment. Other ORL indicators are the level of crew training and operating skills of a ship, also transmitted along with technical data. Headquarters uses this data to rank ships and tries to assess each ship's ORL. Finally, the head office can monitor the ORL and schedule vessels according to the ratings obtained through the procedures mentioned above (Kocaman, 2009).

2.3. Fifth Generation Warfare.

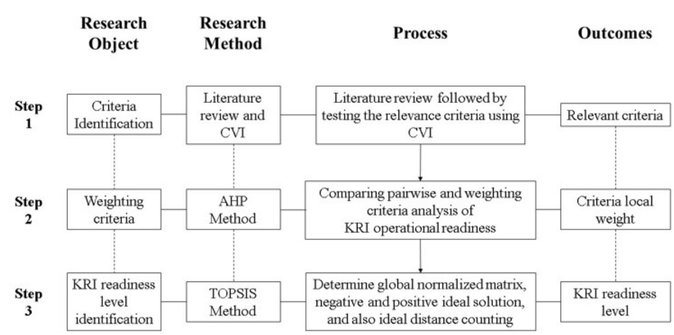
Fifth-generation warfare has arrived and is irreversibly changing the character and nature of human conflict. This confronts the United States with a strategic dilemma that continues to develop, namely not only dealing with the War on Terror, but also developing a strategy that not only looks at military readiness in facing wars in the past, but also includes the perspective of national readiness in facing a spectrum of conflicts in the future. To develop a typology of generational wars and conflicts that informs the characteristics of fifth-generation warfare. The resulting model produces two results: First, it shows how current events such as the rise of computer hackers, the anthrax of 2001, the Ricin attacks of 2003-2004, the Madrid bombings of 2004, and second; The emergence of the Al-Qaeda terrorist group shows the characteristics of fifth generation warfare. This illustrates how these events are unique indicators of a future in which non-state entities are increasingly capable of fighting as equals with nation-states. The article concludes that even a superpower like the United States must embrace fifth-generation warfare if it is to successfully confront threats that have taken new and hitherto unimaginable forms in the era of postmodern warfare (Reed, 2008).

Warfare has developed along with advances in science and technology. The system of mutual attacks between nations has changed in such a way over time. First, the battle system occurs formally and regularly by both parties, which creates an orderly military culture. The next generation, namely the second, enemy conquest system prioritizes using artillery with more sophisticated firepower than previous methods. Unlike before, the technique for defeating opponents in the third period emphasizes strategies including speed, shock, and mental dislocation. Shifting to the fourth type, conflict no longer focuses on other countries as rivals, but on non-states in the form of radicalism movements, revolutionaries, and other similar groups. Then, it evolved into another form which was more complicated than before. The system of hostility between nations had entered the fifth generation, warfare using hidden methods to attack the enemy. Of these types of warfare, the methods of warfare have become more sophisticated than before (Anwarrudin, 2023).

3. Methodology.

This research was carried out on KRI, especially the KRI SIGMA class, which is under the coaching command of Fleet Command II Surabaya. The main aim of this research is to determine the operational readiness level the KRI is currently at, especially when faced with fifth-generation warfare. Questions related to identifying factors that influence operational readiness are prepared using the Saaty scale (1-9) and a five-point Likert scale (1-5). Fifteen experts were selected with a minimum educational background of Bachelor's degree (Khan et al., 2020); (Rioja-Lang et al., 2020); related practitioners (Fallah & Ocampo, 2021); and work period of more than 5 years (Shakeri & Khalilzadeh, 2020); (Kim, 2022). All experts in this study were middle-ranking officers who had experience serving in the KRI for more than 5 years. Their opinions and suggestions helped us compile the data and improve the research results. In Figure 1, the research design, it can be seen that the first step in this research begins with identifying the criteria that influence KRI operational readiness through literature study and testing the relevance of the criteria using CVI. Next, in the second step, pairwise comparisons of the criteria and weighting of the criteria are carried out using the AHP method until the value of the local weight of the criteria is obtained. The final step, namely the third step, is to identify the level of operational readiness using the TOPSIS method, the results of which are then tested through several scenarios at the sensitivity analysis stage to analyze the robustness of the decisions presented (Dogan, 2021).

Figure 1: Research design.



Source: Author.

3.1. Conceptual Framework.

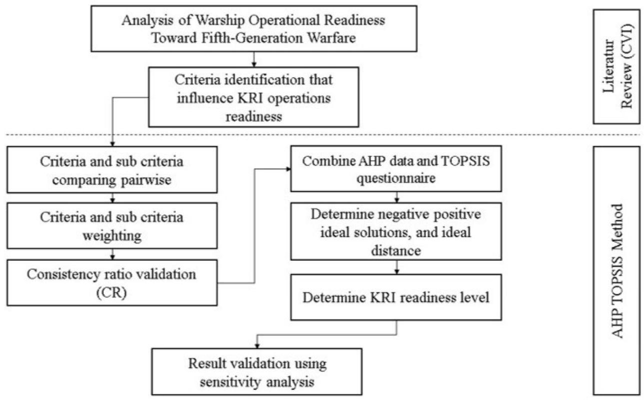
The conceptual framework developed in this research is presented in Figure 2. The research objectives consist of three parts, namely:

- Identify the criteria that influence KRI operational readiness.
- Identify the KRI operational readiness level.
- Validate results and models using sensitivity analysis.

This research uses the AHP and TOPSIS techniques because of the advantages they have as follows (Amudha et al., 2021). The model mechanism is illustrated in the conceptual framework shown in Figure 2, which is divided into three phases of modification (Putra et al., 2023).

Phase 1 – This article determines the research object studied, namely the KRI SIGMA class, determines the criteria that influence the KRI's operational readiness based on (Kocaman,

Figure 2: Conceptual framework of research.



Source: Author.

2009). This phase ends when consensus for the criteria and type/class of KRI under study has been reached.

Phase 2 – The approach in this manuscript considers nine main criteria. Through literature review and expert opinion, these criteria were identified and validated. Questionnaires are given to obtain responses and assessments in identifying criteria to produce a hierarchical structure which is then used to calculate the weight values of these criteria.

Phase 3 – The KRI's operational readiness level is evaluated based on criteria weight parameters. TOPSIS is used to determine the level of operational readiness of the KRI which can later be used as advice and input for leadership in decision making. The final stage in this phase is the sensitivity analysis of previously processed calculation data to measure and evaluate the robustness of the model under conditions of uncertainty. Sensitivity analyses were also conducted to investigate large and small variations in experts' preferences that might alter the results (Solangi et al., 2019).

3.2. Content Validity Index (CVI).

The data analysis technique in this research uses the Content Validation Index approach (CVI). According to (Ayu Dessy Sugiharni, 2018), Content validity is the extent to which elements of an assessment instrument are relevant and representative of the constructs targeted for a particular assessment objective. Assessment instruments refer to certain methods for obtaining data in psychological assessments such as questionnaires. The elements of an assessment instrument refer to all aspects of the measurement process that can influence the data obtained, such as questionnaire items, response formats and instructions. Construct refers to the concept, attribute, domain, or variable that is the target of measurement. CVI is classified into two types, namely: Item-CVI (I-CVI) and Scale-level CVI (S-CVI). S-CVI is calculated using two methods, namely: S-CVI Average (S-CVI/Ave) and S-CVI Universal Agreement (S-CVI/UA) (Polit, 2007) (Lynn, 1986). The following are the steps for content/substantive validity testing: a) Prepare content validity items; b) Determine the experts who will assess the validity of the content; c) Carrying out content validity tests (face to face, online, and offline); d) Experts review the items and provide a score for each item; and e) Determine the relevance of content validity.

Table 1: Types, Definitions and Formulas of CVI.

CVI Types	Definitions	Formulas
I-CVI (Item-level content validity index)	The portion of content experts who give items a relevance rating of 3, 4 or 5.	**I-CVI** = (agreed items)/ (number of experts)
S-CVI/Ave (Scale-level content validity index based on the average method)	The average I-CVI score of all items on the scale is the average proportion of relevance assessed by all experts. According to individual experts, the relevant proportion is the average of the relevance ratings.	**S-CVI/Ave** = (I-CVI total scores)/ (number of items) $=\frac{\Sigma I-CVI}{number\ of\ item}$
S-CVI/UA (Scale-level content validity index based on the universal agreement method)	The proportion of items on the scale that reach a relevance scale of 3, 4, or 5 by all experts. A universal agreement score is given when the item achieves 100% expert agreement, otherwise, a universal agreement score is 0.	**S-CVI/UA** = (UA total scores)/ (number of items) $=\frac{\Sigma UA}{number\ of\ item}$

Source: Polit, 2006.

3.3. Analytical Hierarchy Process (AHP).

AHP is Multi-Criteria Decision Making Analysis or Multi-Criteria Decision Making (MCDM). At the pairwise comparison stage, a pairwise eigenvalue approach is used. It also provides a methodology for calibrating numerical scales in quantitative and qualitative performance measurements (Tyagi et al., 2018). The scale ranges from 1/9 for least worth comparing, 1 for equal, and 9 for absolutely more important than, covering the entire comparison spectrum. This method was created by Saaty (1980) at the University of Pittsburgh (Gnanasekaran & Venkatachalam, 2019). AHP provides a relatively simple yet theoretically robust multi-criteria methodology for evaluating alternatives. It allows decision-makers to use simple hierarchical structures to deal with complex problems and evaluate quantitative and qualitative data systematically under multiple conflicting criteria (Saini, 2022). The following are the AHP steps in brief:

1. Determine goals, criteria, and alternatives.
2. Create a questionnaire that will be used as research data.
3. Data processing by carrying out pairwise comparisons (reciprocal) of criteria that have been determined and assessed by experts to produce qualitative figures.
4. Carry out a consistency analysis using the CR (Consistency Ratio) value, with a formula:

$$CR = \frac{CI}{RI} \tag{1}$$

CI (*Consistency Index*),

$$CI = \frac{\lambda\, maximum - n}{n-1} \tag{2}$$

RI (*Random Index*) is obtained from table values.

Table 2: Random Index Values.

n	3	4	5	6	7	8	9	10
RI	0,58	0,9	1,12	1,24	1,32	1,41	1,45	1,49

Source: Authors.

The threshold value of CI is 0.1. It can be interpreted that the level of confidence in decision-making is 90% (with 10% errors/inconsistencies). When used, the CI value must be below 0.1 to get the desired results.

3.4. Technique for Order Preference by Similarity to Ideal Solution (TOPSIS).

In the TOPSIS process, performance rankings and criteria weights are given as appropriate values for solving multi-objective nonlinear programming problems. TOPSIS provides the decision maker with the closest alternative that is considered the best according to the score illustrated by his decision. Thus, if one decision maker gives a score to each alternative, the result will be a ranking of alternatives based on that score. If other decision-makers give different scores, then the ranking of the alternatives will be different (Marzouk & Sabbah, 2021). TOPSIS is a tool for decision-making that uses the concept of a proximity index to a positive ideal solution (Lai et al., 1994). This concept was developed by Hwang and Yoon (1981) by assuming that, in a decision-making problem with m criteria and n alternatives, several alternative points n can be mapped on a space of m dimensions. Hwang and Yoon assume that the optimal solution is the solution that has the shortest distance to the positive ideal solution and the furthest distance to the negative ideal solution (Jandi, 2020). The following are the TOPSIS steps in brief:

1. Calculating the normalized vector matrix:
   The normalized vector used to calculate, r_{ij}, calculated as follows:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\int_{i=1}^{m} x^{2} ij}},\ i = 1, \ldots, m; j = 1, \ldots, n \tag{3}$$

2. Calculates normalized ratings with weights:
   The weighted normalized rating can be calculated with a formula:

$$v_{ij} = wjrij, i = 1, , m; j = 1, , n \tag{4}$$

   v_{ij} is the weight of the j attribute

3. Identify positive ideal solutions and negative ideal solutions.

$$A^{+} = \left\{ \left(\max v_{\ ij} \,\middle|\, ?J_1 \right),\ \left(\min v_{\ ij} \,\middle|\, ?J_2 \right) \middle| i = 1,\ \ldots,\ m \right\} \tag{5}$$

$$A^{+} = \left\{ \left(\min v_{\ ij} \,\middle|\, ?J_1 \right),\ \left(\max v_{\ ij} \,\middle|\, ?J_2 \right) \middle| i = 1,\ \ldots,\ m \right\} \tag{6}$$

   J_1 is a positive attribute (benefit), J_2 is a negative attribute (cost)

4. Calculate distance:
   The concept of calculating the distance between a positive ideal solution and a negative ideal solution using the Euclidean formula is as follows,

$$di^{+} = \sqrt{\int_{j=1}^{n} (v_{ij} - v_j)^{2}},\ i = 1,\ \ldots,\ m \tag{7}$$

$$di^{-} = \sqrt{\int_{j=1}^{n} (v_{ij} - v_j)^{2}},\ i = 1,\ \ldots,\ m \tag{8}$$

5. Calculate the proximity index:
   Calculating the proximity index to the positive ideal solution with the formula;

$$S\,i^{+} = \frac{di}{di^{+} di^{-}},\ i = 1, \ldots, m \tag{9}$$

6. Sort the results by order $S\,i^{+}$ largest as the optimal solution.

Table 3: Pairwise comparison scale for AHP and Likert for TOPSIS.

Saaty Scale	Definition	Explanation	Likert Scale	Information
1	Both criteria are equally important	Both criteria have equally important contributions to analyzing KRI operational readiness	1	Very low
3	One criterion is slightly more important than the others	One criterion has a slightly more important contribution than the other criteria in analyzing KRI operational readiness	2	Low
5	One criterion is more important than the other	One criterion has a more important contribution than the other criteria in analyzing KRI operational readiness	3	Moderate
7	One criterion is more important than the others	One criterion has a more important contribution than the other criteria in analyzing KRI operational readiness	4	High
9	One criterion is absolutely more important than the others	One criterion has an absolutely more important contribution than the other criteria in analyzing KRI operational readiness	5	Very high
2,4,6,8	The middle value between two adjacent considerations	Given if there is doubt between two adjacent assessments	-	-

Source: Authors.

Table 4: KRI operational readiness level.

Score	Readiness Level	Description
0-0,2	Zero Readiness	The unit is not ready/seriously damaged.
0,21-0,4	Very Elevated Readiness	A unit that is not yet fit to carry out its mission. Units will require extensive upgrades before combat.
0,41-0,6	Elevated Readiness	A unit that has deficiencies large enough to limit the unit's depth. Its ability to achieve the mission it is organized to serve as its goal. Units will require an intensive preparation period before combat except in emergencies.
0,61-0,8	Medium Readiness	A unit that has some shortcomings that limit its ability to accomplish its organized mission. Units can be immediately deployed to combat areas.
0,8-1	Maximum Readiness	A unit that is fully capable of carrying out the mission for which it is organized. Units can be immediately deployed to combat areas.

Source: Finley et al., 2021.

4. Result & Discussion.

4.1. Determination of KRI criteria and alternatives.

At the initial stage of application, criteria for factors that influence KRI operational readiness and KRI alternatives must be determined. Identification of criteria that influence the analysis of KRI operational readiness was obtained from literature studies and previous studies supported by expert opinion and then validated using CVI. Data processing was then carried out using AHP and TOPSIS techniques and ended with a sensitivity analysis process.

Fifteen sources from mid-level Indonesian Navy officers who were competent in analyzing KRI operational readiness were surveyed to determine the importance of the criteria. By the survey results, the criteria with the highest total score form the input hierarchy entry that will be used in weighting the criteria. All criteria that influence decisions in determining the KRI operational readiness level are determined by experts/resources. The criteria that influence KRI operational readiness are based on literature studies from (Kocaman, 2009) which is applied in identifying operational readiness level factors on United States warships or United States Ships (USS). The following three criteria include: a) Personnel training level (C1); b) Ship operational skills (C2); c) Material readiness level (C3).

a) Level of personnel training.

The level of personnel training on warships is a crucial aspect in ensuring that ship members have the knowledge, skills, and readiness necessary to carry out their operational duties effectively and safely at sea. These personnel training level criteria were then developed into several sub-criteria, namely: Advanced stage training (SC1), Glagaspur L1-L2 training (SC2); TNI AL and TNI integrated training (SC3); and Joint training with foreign navies (SC4).

b) Ship operational skills.

Warship operational skills refer to the set of technical, tactical, and operational capabilities required to operate a warship effectively in various situations. The criteria for ship operational skills were further developed into several sub-criteria, namely: Operation experience (SC5) and maintenance skills (SC6).

c) Level of material readiness:

The level of material readiness on a warship refers to the condition and availability of critical systems, equipment, and components needed for the ship to operate effectively. High material readiness is essential to ensure the ship is ready for use in various situations, including normal operations, exercises, or combat situations. The criteria for the level of material readiness were then developed into several sub-criteria, namely: Availability of logistics (SC7), Maintenance history (SC8), and Performance (SC9). After identifying the criteria, the content index validation is then carried out using CVI to determine the relevance of the criteria content to the expected objectives.

CVI questionnaire results.

According to Figure 3, 15 expert panels received a questionnaire describing and explaining the research and its objectives. A questionnaire consisting of 12 items as an assessment tool was distributed to experts using a Likert scale of 1-5, estimated completion time of 10-15 minutes. Item CVI ranged from a minimum of 0.78 to a maximum of 1, validating all instrument items. No one from the expert panel suggested changing any themes or indicators. For almost all items, the I-CVI value was 1, representing 99.4% agreement among experts with an S-CVI of 80%. The I-CVI is considered very good, thus completing the overall validity stage. The results of research using the CVI method showed that 12 criteria influenced the analysis of KRI operational readiness.

Table 5: CVI questionnaire results.

	Criteria	Validation		Final
		CVI	Result	Result
1	Personnel training level	1	accepted	accepted
2	Advanced stage training	1	accepted	accepted
3	Glagaspur L1-L2 training	1	accepted	accepted
4	TNI AL and TNI integrated training	0.93	accepted	accepted
5	Training with foreign navies	1	accepted	accepted
6	Ship operating skills	1	accepted	accepted
7	Operation experience	1	accepted	accepted
8	Maintenance skills	1	accepted	accepted
9	Material readiness level	0.93	accepted	accepted
10	Logistics availability	1	accepted	accepted
11	Maintenance history	1	accepted	accepted
12	Performance	1	accepted	accepted

*accepted if mean >3.00; S-CVI/Ave > 0.90; if the number of experts is > 9, I-CVI ≥ 0.78.

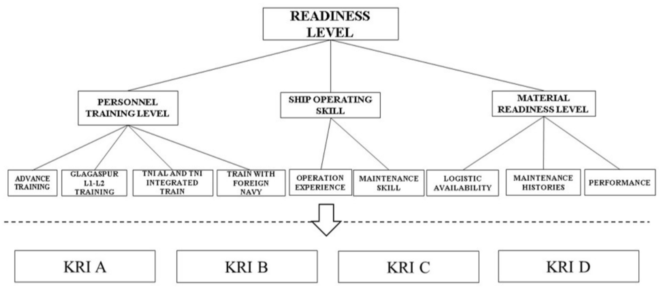
Source: Authors.

Next, the research objects were determined in the form of four KRI SIGMA class units which were used as alternatives in this research, namely: a) KRI A, b) KRI B, c) KRI C, and d) KRI D. Then, evaluated according to the planned methodology.

4.2. Criteria weighting and analysis of KRI operational readiness levels.

As seen in Figure 3, the problem hierarchy structure has been built based on criteria and alternatives. After obtaining data in the form of assessments from experts to develop KRI operational readiness criteria, the Microsoft Excel application was used to complete the approach. The results of pairwise comparisons of criteria and sub-criteria using the AHP technique can be seen in Table 6. Pairwise comparison results for Criteria and Sub-criteria.

Figure 3: Hierarchical analysis structure of research.



Source: Authors.

Table 6: Pairwise comparison results for Criteria and Sub-criteria.

Criteria	Weight	Sub Criteria	Code	Local Weight	Total Weight	Rank
Personnel training level	0.138	Advance stage training	SC1	0.081	0.011	8
		Glagaspur L1-L2 training	SC2	0.065	0.009	9
		TNI AL and integrated TNI training	SC3	0.105	0.014	7
		Training with foreign navy	SC4	0.165	0.023	6
Ship operating skills	0.368	Operations experience	SC5	0.070	0.026	5
		Maintenance skills	SC6	0.104	0.038	3
Material readiness level	0.493	Logistics availability	SC7	0.156	0.076	2
		Maintenance histories	SC8	0.074	0.036	4
		Performance	SC9	0.176	0.087	1

Source: Authors.

In Table 6, after processing the data above to obtain a valid questionnaire, in the criteria column with the number of criteria elements being 3, the constant for determining the Ratio Index is 0.58. It is known that the CI value is 0.0572 and the CR value is 0.0987 (9.87%), so the data is concluded to be "consistent" because it is still below 0.1 (10%). The criterion that has the highest weight is the level of material readiness (0.4931), followed by ship operational skills (0.3681) and the level of personnel training (0.1386).

Next, in the sub-criteria column, with the number of sub-criteria elements being 9, the constant for determining the Ratio Index is 1.45. It is known that the CI value is 0.1442 and the CR value is 0.0994 (9.94%), so the data can be concluded to be "consistent" because it is still below 0.1 (10%).

The sub-criteria that has the highest weight is aircraft performance (0.1767) followed by eight other sub-criteria, namely joint training with foreign navies (0.1659), logistics availability (0.1560), TNI AL and TNI integrated training (0.1059), maintenance skills (0.1040), advanced training (0.0813), maintenance history (0.0746), operating experience (0.0707), and L1-L2 glagaspur training (0.0650).

The data processing process continues with a questionnaire given to experts to be processed using the TOPSIS technique. At this stage, the expert gives a score between 1 and 5 points for the alternative that has been determined (Likert scale 1-5).

Table 7: Local normalized matrix.

CRITERIA	C1				C2		C3		
Weight	0.1386				0.3682		0.4932		
SUB CRITERIA	SC1	SC2	SC3	SC4	SC5	SC6	SC7	SC8	SC9
Local value	0.081	0.065	0.105	0.165	0.070	0.104	0.156	0.074	0.176
ALT									
KRI A	2.800	3.066	3.000	3.266	3.600	2.800	3.200	3.600	3.133
KRI B	2.933	2.866	2.800	3.266	3.200	3.266	3.133	3.466	3.200
KRI C	3.133	3.133	2.933	3.066	3.333	3.133	3.133	2.866	3.200
KRI D	3.333	3.200	2.933	3.333	3.200	3.133	3.266	2.733	3.066

Source: Authors.

Table 8: Globally valued weighted normalized decision matrix.

ALT	C1				C2		C3		
	SC1	SC2	SC3	SC4	SC5	SC6	SC7	SC8	SC9
KRI A	0.031	0.027	0.044	0.075	0.093	0.107	0.246	0.132	0.273
KRI B	0.033	0.025	0.041	0.075	0.083	0.125	0.241	0.127	0.278
KRI C	0.035	0.028	0.043	0.070	0.086	0.119	0.241	0.105	0.278
KRI D	0.037	0.028	0.043	0.076	0.083	0.119	0.251	0.100	0.267

Source: Authors.

Table 9: Positive Ideal Solution and Negative Ideal Solution.

PIS	0.037	0.028	0.044	0.076	0.093	0.125	0.251	0.132	0.278
NIS	0.033	0.025	0.041	0.070	0.083	0.006	0.241	0.100	0.267

Source: Authors.

Table 10: Calculation of Euclidean distance and proximity index.

ALTERNATIVES	d+	d-	s
KRI A	0.0205	0.1068	0.8392
KRI B	0.0167	0.1225	0.8802
KRI C	0.0309	0.1145	0.7878
KRI D	0.0359	0.1145	0.7613

Source: Authors.

Table 11: Results of determining the level of readiness of KRI operations.

ALTERNATIVES	s	READINESS LEVEL
KRI A	0.8392	Maximum
KRI B	0.8802	Maximum
KRI C	0.7878	Medium
KRI D	0.7613	Medium

Source: Authors.

The TOPSIS method is used to determine the level of operational readiness. According to (Finley et al., 2021), the alternative is 4 KRI SIGMA class units. Researchers obtained data from the TOPSIS questionnaire and then combined it with previously obtained AHP data, the results of which can be seen in Table 7 Local normalized decision matrix. Furthermore, in Table 8, a global weighted normalized decision matrix is obtained by multiplying each criterion, sub-criteria, and alternative value. The positive and negative ideal solutions can be seen in Table 9, obtained from determining the 2 highest and lowest values for each sub-criteria for the alternative. Calculations of Euclidean distance and closeness index can be seen in Table 10.

Based on Table 11, it can be seen that KRI B is an alternative that has the highest value of 0.8802 at the maximum readiness level. Followed by KRI A with a value of 0.8392 at the maximum readiness level, KRI C with a value of 0.7878 and KRI D with a value of 0.7613, both of which are at the medium readiness level.

4.3. Sensitivity analysis.

Sensitivity analysis is the study of how uncertainty in the output of a mathematical model or system (numerical or otherwise) can be apportioned to different sources of uncertainty in its inputs. Uncertainty analysis, which focuses more on measuring and propagating uncertainty, is a similar technique. Optimally, uncertainty and sensitivity evaluations should be performed simultaneously. Under sensitivity analysis, the process of recalculating results based on different assumptions to identify the influence of a variable can serve various purposes. The main objective is to evaluate the robustness of the model under conditions of uncertainty (Saini & Singh, 2022). Different scenarios were investigated by keeping the weight of one criterion as a derivative, while the other criteria were given the same weight in Table 12. Scenarios with changed weights were checked for deviations from the original results. In the first scenario, the weight of the advanced training criteria is maintained, while the other eight criteria are given the same weight.

Table 12: Several scenarios/tests are given with varying weights.

	BASIC VALUE	TEST 1	TEST 2	TEST 3	TEST 4	TEST 5	TEST 6	TEST 7	TEST 8	TEST 9
SC1	0.081	**0.081**	0.116	0.111	0.104	0.116	0.112	0.105	0.115	0.102
SC2	0.065	0.114	**0.065**	0.111	0.104	0.116	0.112	0.105	0.115	0.102
SC3	0.105	0.114	0.116	**0.105**	0.104	0.116	0.112	0.105	0.115	0.102
SC4	0.165	0.114	0.116	0.111	**0.165**	0.116	0.112	0.105	0.115	0.102
SC5	0.070	0.114	0.116	0.111	0.104	**0.070**	0.112	0.105	0.115	0.102
SC6	0.104	0.114	0.116	0.111	0.104	0.116	**0.104**	0.105	0.115	0.102
SC7	0.156	0.114	0.116	0.111	0.104	0.116	0.112	**0.156**	0.115	0.102
SC8	0.074	0.114	0.116	0.111	0.104	0.116	0.112	0.105	**0.074**	0.102
SC9	0.176	0.114	0.116	0.111	0.104	0.116	0.112	0.105	0.115	**0.176**

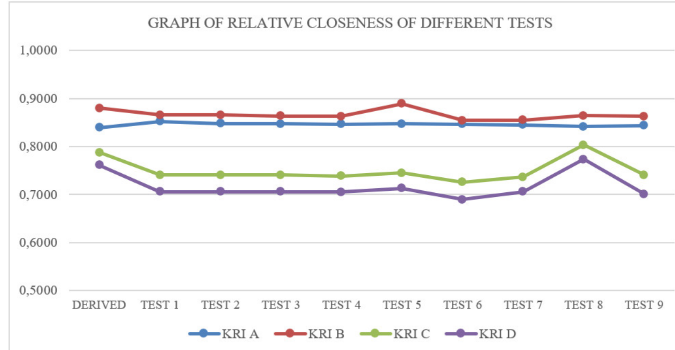
Source: Authors.

Table 13: Relative closeness values obtained from different test scenarios.

ALT	DERIVED	TEST 1	TEST 2	TEST 3	TEST 4	TEST 5	TEST 6	TEST 7	TEST 8	TEST 9
KRI A	0.839	0.852	0.848	0.847	0.846	0.846	0.846	0.845	0.841	0.843
KRI B	0.880	0.865	0.865	0.863	0.862	0.888	0.854	0.855	0.864	0.863
KRI C	0.787	0.741	0.741	0.740	0.738	0.744	0.725	0.736	0.803	0.740
KRI D	0.761	0.706	0.706	0.705	0.705	0.713	0.689	0.705	0.773	0.700

Source: Authors.

Figure 4: Sensitivity analysis results.



Source: Authors.

The results of the sensitivity analysis in the form of a graph can be seen in Figure 4. Based on the nine scenario tests carried out (Table 13), the results obtained are that operational experience (SC5) and maintenance history (SC8) are sub-criteria that influence sensitivity in determining the KRI's operational readiness level.

Table 14: KRI ranking results from sensitivity analysis testing.

ALT	DERIVED	TEST 1	TEST 2	TEST 3	TEST 4	TEST 5	TEST 6	TEST 7	TEST 8	TEST 9
KRI A	2	2	2	2	2	2	2	2	2	2
KRI B	1	1	1	1	1	1	1	1	1	1
KRI C	3	3	3	3	3	3	3	3	3	3
KRI D	4	4	4	4	4	4	4	4	4	4

Source: Authors.

The KRI operational readiness analysis evaluation ranking is known in the order KRI B, KRI A, KRI C, KRI D. Likewise, if the scenario is changed by considering the actual weight of one criterion and giving the same weight to the other criteria, it is shown in Table 12. The relative closeness values obtained from different scenarios are shown in Table 13. The results of the sensitivity analysis are shown in Figure 4. Variations in the evaluation of KRI alternative rankings with different scenarios in the sensitivity analysis are shown in Table 14. It can be seen that there is no variation at all in the ranking order, and KRI B becomes an alternative KRI from the SIGMA class as the first rank with an operational readiness level at the maximum readiness level.

Managerial Implications.

From a managerial perspective, this research provides implications for determining the level of operational readiness for KRI in the future (Surianto & Mustamu, 2014). This study has a theoretical basis for operations management, readiness levels, and fifth-generation warfare. This is used to identify the criteria that influence the analysis of KRI operational readiness in facing fifth-generation warfare, as well as determining the alternative which in this research is the KRI SIGMA class. First, by drawing on insights from several different theories, this research helps to better understand various aspects of the research problem and is an important source of theoretical renewal. (Mayer, 2013). Second, research on analyzing the operational readiness of the KRI facing fifth-generation warfare is relatively new research and will develop according to the war era in the future and will have a significant impact on the maritime sector, especially maritime defense. This model shows a hierarchy of criteria and sub-criteria that influence the analysis of KRI operational readiness. The literature study method and criteria relevance test organize these criteria into a hierarchy and determine 12 sub-criteria. The results show the existence of the level of readiness of KRI SIGMA in facing fifth generation warfare, so that it can be used as reference data in the decision-making process and policy direction.

Practical Implications.

In terms of practical implications, this research provides practical implications in the application of the CVI-AHP-TOPSIS technique in analyzing the readiness of KRI operations faced with fifth-generation warfare (Ali et al., 2022); (Joshi et al., 2011); (Taylor et al., 2012). First, this research can help decision makers so that it can be used as additional knowledge in the decision-making process and policy direction, especially in War Military Operations (OMP) (Anissa & Yuliana, 2022). Second, it is hoped that this research can contribute recommendations for practitioners (central government, military leadership, and other stakeholders, etc.) that facilitate the assessment of the level of readiness of KRI operations faced with fifth generation warfare. It is important to identify key criteria that influence the context of KRI operational readiness analysis. Military practitioners can use this research model to evaluate and prioritize the KRI owned by the Indonesian Navy. They can use the data and information collected to identify their strengths and weaknesses as well as identify existing opportunities and threats to formulate effective strategic policies in the future.

Conclusions.

Research regarding the level of operational readiness of the KRI is quite sensitive research considering that the readiness of a country's defense equipment is a secret matter. However, the development of a strategic environment which is quite dynamic, especially the rapid development and advancement of technology in the field of defense and security, forces us to start identifying the relevance of the defense equipment we currently have with the threat spectrum of fifth generation warfare and the next generation of warfare. Therefore, knowing the level of operational readiness of KRI SIGMA class and other types of KRI or even researching the readiness of other defense equipment such as tanks, fighter aircraft, etc., is valid and important scientific research for military science, marine, and maritime science. In this study, the MCDM method was used to obtain precise data. After that, the AHP method is used to obtain the criteria weighting. Finally, this research uses the TOPSIS method to rank the level of operational readiness of the KRI. Apart from that, researchers also carried out the sensitivity analysis to observe the reliability and effects of possible changes in alternative weights. Researchers determined the changes by testing nine different scenarios.

Based on the research results, the level of material readiness (0.4932) is the criterion with the most important weight, followed by ship operational skills (0.3682) and the level of personnel training (0.1386). Furthermore, aircraft performance (0.1767) is the most important sub-criterion besides eight other sub-criteria, namely joint training with foreign navies (0.1659), logistics availability (0.1560), integrated TNI AL and TNI training (0.1059), maintenance skills (0.1040), advanced training (0.0813), maintenance history (0.0746), operating experience (0.0707), and L1-L2 Glagaspur training (0.0650). Next, at the stage of ranking the level of operational readiness of the KRI, the following results were obtained, namely: KRI B (0.8802) is the KRI with the highest score at the maximum readiness level. Likewise KRI A (0.8392) is also at the maximum readiness level, followed by KRI C (0.7878) and KRI D (0.7613) both are at medium readiness levels. Furthermore, the results of the sensitivity analysis of the KRI alternative ranking with nine different scenarios show that there is no variation at all in the ranking order, and KRI B is the KRI alternative from the SIGMA class as the first rank with an operational readiness level at the maximum readiness level. Thus, the resulting model is strong.

This research provides real implications for qualitative analysis on aspects of the level of readiness of KRI operations in the defense equipment domain of the Indonesian Navy with technological sophistication increasing every year and an increasingly vulnerable spectrum of new types of threats. This research will assist stakeholders in evaluating and developing a framework for KRI operational readiness levels as a first step in determining policy strategies by adopting the solutions provided in the research.

There are several limitations in this research. First, this research is devoted to evaluating the value of the KRI's operational readiness level. However, it does not yet discuss the next step, namely the development of the next generation war vulnerability risk analysis model in Indonesian maritime areas. Future studies can discuss risk analysis using the same method but with different criteria and alternatives in the future. Second, for further studies, comparison of other methodologies with different multi-criteria decision making techniques such as Linear Programming Technique for Multidimensional Analysis of Preference (LINMAP), Borda Count, Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE), and Data Envelopment Analysis (DEA) can be used, and the results of its application in different areas can be presented. Third, this research does not discuss threat mitigation strategies as a response to reducing the risk of threats and impacts arising from fifth-generation warfare. Future research could continue these studies.

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