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PRIORITY DETERMINATION OF SUBMARINE TYPE AS DEFENSE OF ARCHIPELAGIC WAR WITH FUZZY AHP METHOD AND BCR ANALYSIS

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ABSTRACT

This thesis describes the application of the Fuzzy Analytical Hierarchy Process (Fuzzy AHP) approach and Benefit Cost Ratio (BCR) analysis in submarine selection. Submarines as Main Defenses System which are highly strategic in their procurement are directed at realizing a deterrence strategy and a strategy of balancing with state actors that have the potential to threaten the sovereignty of the Indonesian state. Apart from threats, the procurement of submarines also considers Indonesia's geographic constellation and the government's wishes, such as the interest of the minister of defense during working visits to countries that offer their submarines. The first step in procurement is to make an analysis in terms of selecting submarine alternatives, both analysis of information and identification of various important and interrelated requirements regarding data from submarine alternatives that will be selected later. Uncertainty from the government is a fuzzy'nes decision, so this condition can be resolved with the Fuzzy AHP approach and strengthened by BCR analysis, so that the results can provide a higher contribution. The results obtained from the Fuzzy AHP method are the priority order of selecting alternative submarines, namely Y-Class (0.398), W-Class (0.220), X-Class (0.191) and Z-Class (0.191). Where the results of the importance of the main criteria are sequential starting from the Strategic Requirement (Strareq) criteria of 0.409, Operation Requirement (Opsreq) of 0.318 and Technical Requirement (Techreq) of 0.273. Meanwhile, based on the BCR analysis, the Y-Class submarine was also selected with a BCR value of 1.512232936.

Keywords: Fuzzy AHP method, BCR Analysis, Submarine Selection.

1. INTRODUCTION

Figure 1. Indonesian Defence Territory

Indonesia is an archipelagic state which has an area of 8.3 million km² with a coastline of 108,000 km and consists of 17,504 islands (Coordinating Minister for Maritime Affairs, Indonesian Maritime Reference Data, August 2018), thus making Indonesia one of the countries the largest archipelago in the world. Indonesia is also located between two continents, namely the Australian Continent and the Asian Continent, also located between two oceans, namely the Pacific Ocean and the Indian Ocean, so that Indonesia's territorial waters are the main route for world trade activities (Sea Lanes of Trade/ SLOT) and world communication channels. (Sea Lanes of Communications/ SLOC). In the territorial waters of Indonesia, there are many maritime accesses in the form of the Strait, the Intermediate Sea and the choke points that connect ZEEI and the inland seas, including the Malaka Strait, the Sunda Strait, the Lombok Strait and the Makassar Strait. The state of Indonesia has a strategic geographic constellation and conditions and has abundant natural resources, this condition provides benefits for the welfare of the nation, but on the other hand there is a vulnerability to the presence of the interests of other countries that can interfere with the sovereignty of the Republic of Indonesia, both in the form of military and non-military threats.

The Indonesian Navy as the main component at sea in accordance with its role, function and duties as mandated in Law No. 34 of 2004 concerning TNI in article 9, is the main component of State defence at sea which is responsible for carrying out the duties of the TNI in the maritime sector in the field of defence, law enforcement and maintaining security in the marine area of national jurisdiction in accordance with the provisions of national law and ratified international law, carrying out Navy diplomacy in

the context of supporting foreign policy stipulated by the government, carrying out TNI duties in the development and development of force dimensions. sea and carry out empowerment of marine defence areas. In order to carry out its duties optimally, the Indonesian Navy needs the Main Weapon System Equipment (Alutsista) that meets the needs, not only in adequate numbers, but also in accordance with operational requirements and Technical Requirements and cannot be separated from considerations. Strategic Requirements.

Submarines are the main tool of the defence system with very strategic value, where the procurement of new submarines is directed at realizing a deterrence strategy and a strategy of balancing with state actors that have the potential to threaten the sovereignty of the Republic of Indonesia. The procurement of new submarines is also a plan to develop the capability of the forces so that they can maintain the professionalism of the Indonesian Navy. The essential functions carried out by submarines include: Surveillance and Reconnaissance, Organizing Anti-Surface Ship Warfare, Conducting Underwater Warfare including Anti-Submarine Warfare, Infiltration Facilities (Infiltration of Special Forces, activities spying, sabotage, Limited Mine Deployment, and Combat SAR). By considering the basic functions mentioned above, the required submarine is expected to meet the operational and technical requirements of the submarine.

Selection of a submarine alternative that is truly appropriate requires analysis of information and identification of various important requirements regarding data from submarine alternatives which broadly include operational requirements, namely: crew training, interoperability, speed of technological mastery, and variations in submarine capabilities. as well as the technical requirements of the submarine which includes several basic considerations that support operational requirements. In addition, the government's desire in selecting the type of submarine is also the main data in selecting an alternative submarine, such as some time ago on January 13, 2020, Indonesian Defence Minister Prabowo Subianto visited C-country and expressed an interest in buying a Y-Class diesel-electric submarine and a B-country offer. During a visit to this country on November 27, 2019 with the superior product of the X-Class submarine, a license from Germany as well as an offer from D-country with Z-Class which was presented in February 2020 in a limited seminar invitation at BPPT, while now Indonesia is already producing submarines domestically made with assistance from A-country, namely three Improved types 209/1400 W-Class. Uncertainty from the government is a fuzzy'nes decision, so this condition can be resolved by using Fuzzy AHP approach. The Fuzzy AHP method is also known as Conventional AHP or Advanced AHP, which combines the logic of uncertainty (fuzzy logic), which considers the existence of uncertainty and doubt, with an interval at each rank, so that it can be used for decision making of a complex problem (Vahidnia at all, 2008)

2. LITERATURE REVIEW

2.1 The Class of Submarine

There are several classes of submarine that possible to be part of the Indonesian submarine.

a. W-Class submarine.

W-Class submarine DSME improved type 209/1400 with assistance from A-country. This type of conventional diesel-electric submarine is an adaptation of the Type 209 diesel-electric submarine originally developed by Germany's Howaldtswerke - Deutsche Werft – (HDW). The prototype submarine of this type combines the design of the German 2019/1300 type with the A-country W-class, making it a new type of submarine in the world. The absence of a license from HDW Germany made some basic equipment undergoing modification, coupled with the absence of international classifications and registers in shipbuilding so that the ship did not have clear standards. In general, the data is almost the same as the submarine type 209/1300 Cakra class belonging to the Indonesian Navy, only the weight (displacement) is greater.

Figure 2. W-Class Submarine

b. X-Class submarine

X-Class made in B-country licensed from Germany. The submarine is planned to be produced at the Savunma Teknolojileri Muhendislik VeTecaret as (STM) shipyard in Turkey in collaboration with Thyssenkrupp Marine System (TKMS), Germany. This submarine is equipped with a Fuel Cell (Air Independent Propulsion / AIP) and complete sewaco (Cilyndrical Array Sonar, Passive Ranging Sonar, Flank Array Sonar, Cilyndrical Transducer Array, Towed Array

Sonar, Intercept Array Sonar, Radar, ESM and Optronic).

Figure 3. X-Class Submarine

c. Y-Class submarine

Y-class submarine is made in C-country. The Y-Class submarine is a diesel electric attack class submarine made by the French company DCNS equipped with diesel propulsion and auxiliary air-independent propulsion (AIP). The Y-Class was built specifically for export and uses the Submarine Tactical Integrated Combat System (SUBTICS) combat system which is also applied to French Navy nuclear submarines. In addition, the Y-Class submarine has high quiet technology, making it difficult for opponents to spot. Scorpene is claimed to have radar technology that can detect long distances with attack power which also cannot be underestimated.

Figure 4. Y-Class Submarine

d. Z-Class submarine.

Z-Class made in D-country. The submarine that acts as deep-water superiority is worthy of being carried by D-country Z-Class submarines. Acting as a submarine chaser, Z-Class submarine capabilities are not underestimated. Even America chartered it to be used as a training submarine, with Z-Class playing the enemy and the US trying to learn how to defeat a silent diesel electric ship.

Figure 5. Z-Class Submarine

2.2 Fuzzy AHP

Fuzzy Logic for Decision Support. Fuzzy logic is one of the building blocks of soft computing. Fuzzy logic was first introduced by Prof. Lotfi A. Zadeh in 1965. The basis of fuzzy logic is the theory of fuzzy sets. In fuzzy set theory, the role of membership degree as a determinant of the existence of elements in a set is very important. The value of membership or the degree of membership or membership function is the main characteristic of reasoning with fuzzy logic (Kusumadewi et al., 2010).

2.3 Fuzzy AHP

The use of AHP in Multi Criteria Decision Making (MCDM) problems is often criticized due to the inability of the AHP approach to overcome the imprecision factor experienced by decision makers when they have to provide a definite value in the pairwise comparison matrix. Therefore, to overcome the existing weaknesses of AHP, a method called fuzzy AHP was developed. AHP fuzzy method is a combination of AHP method and fuzzy approach.

2.4 Benefit Cost Ratio (BCR) Analysis

BCR analysis is usually carried out by looking at the ratio of the benefits of a project to the general public against the costs incurred by the government. Mathematically this is formulated as follows:

$$\text{BCR} = \frac{Benefit\ (B)}{Cost\ (C)}$$

If the comparison results of B / C> 1, and has the highest value it means that it is profitable. And if the comparison results of B / C <1, it means that it is not profitable and not worthy to be prioritized.

3. RESEARCH METHODOLOGY

3.1 Research Approach

In this study, the authors used a quantitative analysis research approach in which data collection was carried out directly from the respondents, both from the results of interviews and filling out questionnaires related to development strategies. The data obtained from the processing of this questionnaire are used to determine the weight of each criterion and the weight of each alternative based on qualitative criteria. In processing the data, the fuzzy method is used to quantify qualitative data (data that is uncertain).

3.2. Data Sources, Subjects and Research Objects

After carrying out the initial identification and knowing the research objectives, the next stage the researchers looked for data sources

related to submarines and the methods used in the study. Determination of the subject and object of research also needs to be presented in order to provide accurate information in carrying out the research.

3.3. Research design

The research design is a guideline in carrying out the research stages from obtaining or collecting data, managing data, analysing data and evaluating the data, testing data sensitivity to the final stage of interpreting the research results.

Step I: The AHP method is used to weight the 3 main criteria (Opsreq, Thecreq and Strareq) which are divided into sub-criteria:

a. Operation Requirements (Opsreq) Criteria.

The operational requirements criteria relate to the strategic value of the submarine and the global assessment of national defence interests. In the operational requirements criteria, some of the sub-criteria used as a basis for consideration are as follows:

Table 1. Operation Requirements Sub criteria

Code	Subcriteria	Assessment Parameters
CT	Crew Training	The level of ease of the crew in mastering the operation of the submarine
IP	Interoperability	A systems ability to work with other sustems
KT	Speed ofmastery of familiar technology	Speed of mastery of equipment is related to the similarities/differences in technology
VK	Variety of Submarine Capabilities That Must Be Owned	Variations in the ability of the submarine to lead to shallow, medium or deep waters

a. Technical Specification Require-ments (Techreq) Criteria.

In the technical requirements criteria that are considered in determining the selection of submarines related to technology and support systems. The technology that is owned will greatly affect the performance of Alutsista which can benefit its users. There are several sub-criteria to consider:

Table 2. Technical Requirements Sub criteria

Code	Sibcriteria	Asseement Parameters
ST	Technical Specifications	Design and technical criteria contained in the submarine
MI	*Maintenance*& ILS (*Integrated Logistic Support*)	Maintenance standards, ease of getting spare parts and availability of ILS software by the manufacture
CE	*Cutting Edge of Technology*	The popularity of submarine technology that has been produced
AG	Adaptation to SuppoGeography and climate	Air conditioner performance faced with the tropical climate of Indonesia
FS	Supporting Facilities	Thr availability of supporting facilities including the safety of the ship draft

b. Strategic Requirements Criteria.

The strategic requirements criterion is the final criterion in determining the type of submarine suitable for inclusion in the Indonesian Navy fleet, related to the current and future national defence strategy, including several sub-criteria:

Table 3. Strategic Requirements Sub criteria

Code	Subcriteria	Assessment Parameters
PT	Development of AIP Technology	Availability of AIP at initial or additional procurement
KP	Completeness of Safety Equipment	Safety technology and design submarine platform are concerned with safety and security
EK	Effect of The Sustainabulity of The Nasional Industry	Availability of facilities and human resources in accordance with submarine performance
PS	Historical Considerations	History of shipyard making submarine by the country of manufacture
KM	MEF Fulfillment Speed	Submarine design and prototypes and prices to meet the number of submarines
DE	Detterence Effect	Ability of weaponry, level of noise and superiority that other countries fear
HP	ToT Results and processes	ToT offer statement by the country of manufacture

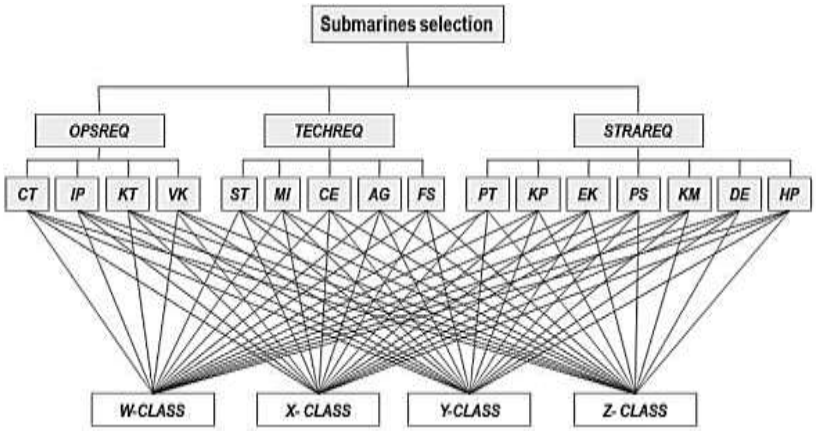

Figure 6. Submarine Selection Hierarchy Model

Step II: Selection of submarine alternative priorities using Fuzzy AHP method.

By using the Fuzzy AHP method, the results of submarine selection will be known based on operating requirements Technical requirements and strategic requirements.

Step III: From the priority of selecting the selected submarines, a sensitivity analysis and BCR analysis are carried out.

4. ANALYSIS AND DISCUSSION

4.1 Data Analysis and Research Results

4.1.1. Pairwise Comparation

In this study, the pairwise comparison process was carried out with the help of the Expert Choice V11 software. With this software allows a relatively fast calculation time. The results of the assessment processed in AHP processing are the average (Geomean) of 7 (seven) respondents who are considered experts in their fields.

Furthermore, the results of the pairwise comparison calculation against the main criteria are shown in the image below:

Figure 7. Pairwise Comparison of Main Criteria

4.1.2 Consistency Ratio

Based on the results of pairwise comparisons of all the main criteria and sub-criteria of the 7 correspondents, the results of the consistency ratio showed that the overall value of CR≤ 0.1. After all data is known to be consistent with CR ≤ 0.1, the calculation can be continued using Fuzzy AHP.

Figure 8. Inconsistency Value

4.1.3 Fuzzy AHP Method

Before weighting the criteria using AHP Fuzzy, a process of changing the results of the respondents with Triangular fuzzy numbers is carried out. In this study, the numbers used are TFN. TFN fuzzy number consists of a range of values, namely (c, a, where c is the lower limit of the pessimistic interest value, a is the middle limit or a more important value, b is the upper limit which is the value of optimistic interest. From the initial matrix of decision makers (R1, R2, R3, R4, R5, R6, R7) it is translated into linguistic variables.

The assessment of the level of importance between the main criteria using the Fuzzy AHP method can be seen in Table 5. Below:

Table 4. Assessment of the Level of Interest among Main Criteria by 7 Respondents using the Fuzzy AHP Method

Criteria		*Opsreq*			*Techreq*			*Strareq*		
		c	a	b	c	a	b	c	a	b
Opsreq	R1	1	1	1	0,333	1	1	1	2	4
	R2	1	1	1	0,333	1	1	0,333	1	1
	R3	1	1	1	0,25	0,50	1	0,333	1	1
	R4	1	1	1	0,333	1	1	0,333	1	1
	R5	1	1	1	1	2	4	1	2	1
	R6	1	1	1	0,333	1	1	1	2	4
	R7	1	1	1	0,25	0,50	1	0,25	0,50	1
Techreq	R1	1	1	3	1	1	1	1	3	5
	R2	1	1	3	1	1	1	1	2	4
	R3	1	2	4	1	1	1	1	2	4
	R4	1	1	3	1	1	1	0,333	1	1
	R5	0,25	0,50	1	1	1	1	0,333	1	1
	R6	1	1	3	1	1	1	1	2	4
	R7	1	2	4	1	1	1	0,333	1	1
Strareq	R1	0,25	0,50	1	0,20	0,333	1	1	1	1
	R2	1	1	3	0,25	0,50	1	1	1	1
	R3	1	1	3	0,25	0,50	1	1	1	1
	R4	1	1	3	1	1	3	1	1	1
	R5	0,25	0,50	1	1	1	3	1	1	1
	R6	0,25	0,50	1	0,25	0,50	1	1	1	1
	R7	1	2	4	1	1	3	1	1	1

4.1.4 Geometric Mean

The next step is to recap all the results of the respondent's assessment and calculate the geometric mean of the lower limit value (c); middle value (a); and the upper limit value (b). Here is the formula used to calculate the geometric mean:

$$c = \sqrt{c1\ c2 \dots cn}$$

$$a = \sqrt{a1\ a2 \dots an}$$

$$b = \sqrt{b1\ b2 \dots bn}$$

Below is a table of the results of calculating the geometric mean for the main criteria related to the objective:

Table 5. Pairwise Comparison Matrix for Main

Criteria	*Opsreq*			*Techreq*			*Strareq*		
	c	a	b	c	a	b	c	a	b
Opsreq	1	1	1	0,359	0,906	1,219	0,512	0,219	1,486
Techreq	0,82	1,104	1,038	1	1	1	0,624	1,575	2,280
Strareq	0,552	0,82	1,952	0,439	0,635	1,601	1	1	1

4.1.5 Benefit Cost Ratio (BCR) Analysis

The purpose of using BCR analysis in this study is to provide alternative results in data processing, in addition to those produced by the Fuzzy AHP method. Thus, researchers used a combination of Fuzzy AHP and BCR methods in carrying out data processing. After obtaining the submarine alternative priority, then selecting the best alternative by considering the cost of each alternative to be selected, then carried out the calculation of BCR.

From the BCR calculation for submarine selection, assuming a year-round operation (360 days) with a total operating time of 100 days, the base price for Solar Industry Area I is IDR 10,337.69 (period 1-14 October 2020) at an exchange rate. dollar bill IDR 14,158.30.

With the alternative priority that has been previously obtained, we can calculate the value of the BCR, because this priority is an element of Benefit that can be combined with the Cost element.

Based on the calculation of BCR, it is known that the Y-Class has a BCR value of 1.512232936 (profitable). While other submarine options are not profitable because the comparison results of B / C <1 with the W-Class order of 0.928425434, Z-Class of 0.806794365 and finally X-Class has the lowest BCR value of 0.725922968.

4.2 Discussion

4.2.1 Selected Submarines Based on Criteria and Subcriteria.

From the results of data processing using the Fuzzy AHP method, then it is analyzed according to the hierarchical structure to produce the following weights:

a. Obtained the priority order for selecting submarine alternatives, namely the Y-Class (0.398), W-Class (0.220), X-Class (0.191) and Z-Class (0.191).

b. Weights for each of the main criteria, namely: Strareq criteria have the highest weight rating (0.409), second rank Opsreq Criteria (0.318) and third rank Techreq criteria (0.273).

c. The weight of the sub-criteria is based on each of the main criteria, namely the sub-criteria Opsreq Criteria for sub-criteria variation of submarine capabilities (0.349), Interoperability (0.229), speed of technology mastery (0.216) and crew training (0.206); Techreq criteria for Indonesian geography & climate adaptation (0.302), Cutting edge of technology (0.202), Maintenance & ILS (0.173), technical specifications (0.171) and supporting facilities / systems (0.152); Strareq Criteria Sub-criteria Historical consideration (0.225), completeness of safety equipment (0.169), AIP technology development (0.165), Detterence effect (0.121), Results & Process ToT (0.112), Speed of Compliance with MEF (0.109) and the effect of the sustainability of the national industry (0.099). The sub-criteria for the variation of ability on the Opsreq criterion, the geographic and climatic adaptation sub-criteria on the Techreqcriterion and the historical consideration sub-criteria on the Strareq criterion each rank 1 for the selection of submarine alternatives. When viewed from the weighting results above, to accommodate the other criteria, it can be seen that the selection of submarines is expected to take into account the variation of submarine capabilities, geographical and climate adaptation as well as historical considerations.

4.2.2 Selected Submarine Alternatives Based on Sensitivity Analysis.

From the results of data processing using the Fuzzy AHP method, then a sensitivity analysis was carried out, the results showed that after changing the weight of the sub-criteria (by changing the threshold value, it was increased by 50%, 10%, 5% and decreased by 5% and 10%) showed changes in the alternative weight, but the order of the alternative submarine rankings did not change, namely Y-Class ranked 1, X-Class ranked 2, W-Class ranked 3 and Z-Class ranked last.

4.2.3 Selected Submarine Alternative Based on BCR Analysis.

Based on the calculation of BCR, it is known that the Y-Class has a BCR value of 1.512232936 (profitable). While other submarine options are not profitable because the comparison results of B / C <1 with the W-Class order of 0.928425434, Z-Class of 0.806794365 and finally X-Class has the lowest BCR value of 0.725922968.

5. CONCLUSIONS AND SUGGESTIONS

5.1 Conclusions

Based on the research results, the following conclusions can be drawn:

a. There are 3 (three) main criteria with 16 (sixteen) sub-criteria used to determine the priority of 4 (four) alternative submarines that will be used as the Indonesian Navy's defense equipment, namely:

1) Operation Requirements (Opsreq) with sub-criteria: crew training, intero-perability, speed of technology

mastery, and variations in submarine capabilities;

2) Technical Requirements (Techreq) with sub- criteria: technical specifications, maintenance and ILS, cutting edge of technology, adaptation to Indonesia's geography & climate and supporting facilities / systems; 3) Strategic Requirements (Strareq) with sub-criteria: The development of AIP technology, completeness of safety equipment, the effect of the sustainability of the national industry, historical considerations, speed of MEF fulfilment, deterrence effect and the results & process of ToT.

b. In determining the alternative priority for submarine selection in this study using the Fuzzy Analytical Hierarchy Process (Fuzzy AHP) method and Benefit Cost Ratio (BCR) analysis.

c. Based on data processing with Fuzzy AHP, the selected alternative with the highest weight is Y-Class with a value of 0.398 and based on BCR analysis, Y-Class is also selected because based on the results of data processing, it has the highest BCR value of 1.512232936, meaning that it is the most profitable if you choose the submarine as the Indonesian Navy Main defence system. Thus, it can be used as a reference for the leadership of the Indonesian Navy in determining policies for selecting priority types of submarines as defence for archipelagic warfare.

5.2 Suggestions

Based on the data processing process and the conclusions from the research results, there are several things that make suggestions related to this research:

a. The submarine type priority, namely the Y-Class made by the C-country, which has been analyzed, can be used as material for consideration and input to the top leadership for the selection of the next submarine type as the Indonesian Navy's Main defense system.

b. In addition to using the Fuzzy AHP method and BCR analysis, other research can also be carried out using different methods, or can be combined with other methods, such as Fuzzy ANP and BOCR analysis and the addition of main and sub-criteria for the perfection of existing research.

c. BCR analysis can be further developed by calculating the Life Cycle Cost (LCC) of each alternative submarine, so that the analysis results are more perfect.

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Negara yaitu bahwa Pertahanan negara disusun dengan memperhatikan kondisi geografis Indonesia sebagai negara kepulauan.

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