PATROL SHIP SELECTION ANALYSIS TO SUPPORT MARITIME SECURITY OPERATIONS IN THE WORKING AREA OF LANTAMAL V SURABAYA

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ABSTRACT

In order to maintain maritime security, especially in the Lantamal V Surabaya working area, the patrol ship unit elements must be ready to deal with all incidents with quick responses. Therefore, it is very necessary to have the most precise patrol ship specifications to carry out tasks that are faced with frequent vulnerabilities, and are also faced with a limited state defense budget. This research proposes the use of the integration of the Fuzzy MCDM and BCA methods in selecting the type of Satrol ship. The Fuzzy MCDM method is considered very appropriate for the problem of fuzzy criteria weights. The BCA method is used to analyze the benefits and costs that will occur as a consequence of the operation of the ship. Based on this research, it is concluded that from the available alternatives, the best Patrol ship that should have been selected for the development/ procurement of Satrol ship is "C" Class ship with a value of 0.6073 using the Fuzzy MCDM method and 1.03 using the BCA method. The results of this research are expected to be input and considerations for the leadership of the Indonesian Navy in the development of future Satrol ships.

Keywords : *Satrol ships, Lantamal V, Fuzzy MCDM, BCA*

1. INTRODUCTION

The 1945 Constitution states that the Government is obliged to carry out state defense efforts from all forms of threats, especially military threats originating from foreign countries. One of the national defense forces possessed by the Indonesian nation is the Indonesian Navy which has the main duties listed in the TNI Law No. 34 of 2004, as the enforcer of state sovereignty at sea. In carrying out the duties of the Indonesian Navy, it is determined by the components of the force which include personnel, defense equipment and methods. One of the defense equipment that determines the readiness of the Indonesian Navy in maintaining the integrity of the Republic of Indonesia is a ship.

The KRI elements in the Indonesian Navy are grouped into 7 ship units :Satkor (Excorta ship unit), Satsel (submarine unit), Satfib (amphibious ship unit), Satkat (fast boat unit), Satran (mine ship unit), (Auxiliary ship unit). Which in each ship unit has different roles and functions according to the condition of the waters (state of sea) and the types of violations and crimes that have occurred. The types of threats, violations and crimes that most often occur in Indonesian waters are illegal fishing, illegal logging, human trafficking, ship piracy, smuggling of weapons and violations of territorial borders by other countries. This requires the readiness of our KRI elements. This is inversely proportional to the readiness of the elements the existing KRI elements, in which the number and technical conditions are not supportive of the implementation of these tasks, so it is necessary to procure KRI system equipment to deal with all forms of threats and violations in order to uphold the sovereignty and maintain the integrity of the Republic of Indonesia with all the risks it faces. Procurement of Indonesian Navy defense equipment refers to the national defense policy set by the Ministry of Defense, and is bound to the Minimum Essential Force (MEF) as stipulated in Perkasal No. 5 of 2016 dated 26 April 2016 concerning Basic

Policies for the Development of the Indonesian Navy towards the Minimum Main Strength (MEF). Referring to the MEF in the procurement of defense equipment, in particular the patrol ships (Satrol Class) which will be procured 46 units of KRI Satrol until 2024, this research will select the type of Satrol ship that is most suitable for Indonesian territorial waters faced with types of threats, violations and crimes that often occur. The current condition of the patrol boat (Satrol) Lantamal V Surabaya only has 3 (three) ships namely KRI Salawaku, KAL Warakas and KAL Krait.

With the demands of a large security area, when compared to the strength of the existing elements, it is very necessary to add suitable ships to be assigned to The Lantamal V Satrol. Therefore a comprehensive comparative analysis is required of the best / representative patrol boat alternative for the Lantamal V working area.With the large number of offers and types of Satrol ships, priorities will be determined in using the type of ship based on the role and main function of the patrol boat in front of the the geographical conditions of Indonesian waters which consist of thousands of islands and shallow straits and fast currents. The main role and function of the KRI Satrol apart from maintaining the sovereignty of the NKRI territory is routine patrols limited to Indonesian territorial waters, especially in narrow and shallow water areas / straits, so a patrol boat that has the ability to accelerate speed and high maneuverability is needed as well as a draft that is needed. low.

In carrying out the analysis of the selection of the type of patrol boat, it requires analysis of information and identification of various requirements, including operational requirements (Opsreq.) And technical requirements (Techreq.), Including of course the cost of the KRI procurement contract. Given the budget constraints due to the current Covid 19 pandemic, in choosing the KRI procurement, in addition to considering the two requirements, namely operational and technical, it is necessary to also analyze the criteria that affect the procurement of this defense equipment. So that in this thesis research will use the integration of the methods of Fuzzy Multi Criteria Decision Making (Fuzzy MCDM) and BCA (Benefit Cost Analysis).

In several studies it was stated that, MCDM is a method that refers to the process of screening, prioritizing, ranking, or choosing a set of alternatives. MCDM is very appropriate to be implemented in multi-criteria cases where all alternatives have the criteria weight in nominal form. The BCA method is used to analyze the benefits and costs that will occur as a consequence of the operation of the ship from the calculation results through Fuzzy MCDM. The expected result from this research is the best alternative type of patrol boat for the work area of Lantamal V Surabaya waters which is not only good in meeting the criteria required by the Indonesian Navy, but also efficient and economical in terms of costs.

2. LITERATURE REVIEW

***2.1 Main Duties*.** The main task of the Satrol (Patrol Boat Unit) is to carry out patrols in the areas closest to the coastline or channel which are narrow and quite shallow.

2.2 Operational Requirements for Patrol Boats (Opsreq)

Based on the basic policy of building the Indonesian Navy's strength, as a first step in the procurement of the TNI AL's defense equipment, it is necessary to establish a Wantuada (Procurement Determination Board), in which the procurement of patrol-type vessels needs to be made Operational Requirements which are oriented towards the following matters (Mabesal, 2015):

- Security. The security and safety of the KRI ABK is the main thing that is needed in all types of warships, including patrol unit ships.

- Speed

Speed is a very important part needed by this type of patrol unit ship, because in addition to the main task of fighting, it is also to maintain the security of Indonesia's seas, which consist of archipelagic areas with fast currents and narrow and shallow straits.

- Transfer of Technology (TOT)

The procurement of KRI must consider the Transfer of Technology process, so that in the future the Indonesian people, especially the Indonesian Navy, can manufacture, operate and maintain independently. In addition, the platform and rigging technology level allows it to be upgraded according to technological developments.

- Armament

The patrol unit ship must be able to be armed with a cannon, as a weapon in stopping crime or security disturbances at sea or capable of being provided with more modern weapons.

2.3 Patrol Boat Technical Requirements (Techreq)

Technical requirements are a requirement in the procurement of a KRI which was previously carried out by a team of experts from the Indonesian Navy Headquarters in the field of Platform and Sewaco (Sensor, Weapons and Control) serving in the Navy Procurement Service (Disadal), Navy Material Service (Dismatal) , Naval Airworthiness Service (Dislaikmatal) and Naval Armament and Electronics Service (Dissenlekal). The technical requirements consist of 5 (five) main points, namely Navigation, Platform, Sewaco, Engineering and Electricity (Mabesal, 2015).

2.4 Concept Theory Fuzzy

The concept of this fuzzy theory was initiated by Lutfi A. Zadeh in 1965 with his seminary paper "Fuzzy Sets" (Zadeh, 1965). With this fuzzy theory, it shows that all theories can be used as a basic concept rather than fuzzy / continues membership function. In general, this fuzzy theory can be classified into five main areas, namely:

- *Fuzzy Mathematics*, where the concept of classical mathematics is extended by converting classical sets into fuzzy sets;
- *Fuzzy Logic & Artificial Intelligence*, where estimates for classical logic are introduced as well as expert systems are developed based on fuzzy information / thought forecasts;
- *Fuzzy System*, which includes fuzzy control through a fuzzy approach with process and communication signals;
- *Uncertainty and Information*, where the differences in the uncertainties are analyzed;
- *Fuzzy Decision Making*, where the consideration for optimization problems exists.

2.5 Membership Functions

The membership function is a curve that shows the mapping of data input points into their membership values (often referred to as membership degrees) which have intervals from 0 to 1. One way that can be used to obtain membership values is through the approach. function. There are several functions that can be used:

a. Linear Representation

In a linear representation, the mapping of the input to the degree of membership can be drawn as a straight line. This form is the simplest and also the right choice to approach an unclear concept. There are 2 states of linear fuzzy set, first is the set increment, starting at the value of the domain which has zero degree of membership [0] shifting to the right to the value of the domain which has a higher degree of membership.

Membership Functions:

$$\mu[x] = \begin{cases} 0; & x \leq a \\ (x-a)/(b-a); & a \leq x \leq b \\ 1; & x \geq b \end{cases} \quad (1)$$

Second, it is the opposite of the first. The straight line starts from the value of the domain that has the highest degree of membership on the left side, then moves down to the value of the domain that has the lower membership.

Membership Functions:

$$\mu[x] = \begin{cases} (b-x)/(b-a); & a \leq x \leq b \\ 0; & x \geq b \end{cases} \quad (2)$$

b. Triangle Curve Representation

A triangle curve is basically a combination of 2 (linear) lines.

Membership function:

$$\mu[x] = \begin{cases} 0; & x \leq a \; atau \; x \geq c \\ (x-a)/(b-a); & a \leq x \leq b \\ (c-x)/(c-b); & b \leq x \leq c \end{cases} \quad (3)$$

c. Trapezoid Curve Representation

The trapezoid curve is basically like a triangle shape, except that there are points that have a membership value of 1.

Membership function:

$$\mu[x] = \begin{cases} 0; & x \leq a \text{ or } x \geq d \\ (xa) / (ba); & a \leq x \leq b \\ 1; & b \leq x \leq c \\ (dx) / (dc); & c \leq x \leq d \end{cases} \quad (4)$$

2.6 Triangular Fuzzy Number (TFN)

In TFN, every single value (crisp) has a membership function consisting of three values, each of which indicates the lower value, the middle value and the upper value.

A = (a1, a2, a3)

The membership functions for TFN in the image above are as follows:

$\mu[x] =$ = 0 for x <a1

= $\frac{x-a_1}{a_2-a_1}$ for a_1 <x <a2 (5)

= $\frac{a_3-x}{a_3-a_2}$ for a_2 <x <a3

2.7 Value Defuzzification

Defuzzification is a process of converting and quantity from blurring into a definite quantity, where the output and fuzzy process can be a logical combination of two or more fuzzy membership functions defined according to the universe of discussion. Input and defuzzy process is a fuzzy set obtained from the composition of fuzzy rules, while a number in the domain of the fuzzy set is the resulting output. The defuzzification methods commonly used today are as follows:

a. Centroid Method (Center Of Gravity / COG) In this method, a crisp solution is obtained by taking the center point (z) of the fuzzy area.

b. Bisector Method In this method, the crisp solution is obtained by taking the value contained in the fuzzy domain which has a membership value half of the total membership value in the fuzzy area.

c. Mean of Maximum (MOM) method In this method, the crisp solution is obtained from taking the average value of the domain that has the maximum membership value.

d. Largest of Maximum (LUM) method In this method, the crisp solution is taken from the largest value from the domain that has the maximum membership value.

e. The Smallest of Maximum Method (SOM) In this method, the crisp solution is taken from the smallest value from the domain that has the maximum membership value.

2.8 Linguistic Variables

A linguistic variable is a variable that has a description in the form of a fuzzy number and is more generally a word represented by a fuzzy set. For example, descriptions of linguistic variables for

temperature could be LOW, MEDIUM and HIGH for example where the descriptions are expressed as fuzzy values. (Tsoukalas, 1997). Like algebraic variables that use numbers as their values, while linguistic variables use words or sentences as their values to form a set which we call a set of "terms", each value of the "term" is a fuzzy variable defined based on the base variable. While the base variable itself defines the universe of speech for all fuzzy variables in the set of "terms" (Jantzen, 1998).

2.9 BCA (Benefit Cost Analysis)

Benefit Cost Analysis is a practical way of estimating project benefit, which requires a long and extensive review. In other words, it requires analysis and evaluation from various points of view that are relevant to the costs and benefits it contributes. B / C Analysis is usually done by looking at the ratio of the benefits of a project to the general public against the costs incurred. Mathematically this is formulated as follows:

$$BCR = \frac{\text{Nilai TPV pada Faktor } Benefit\ (B)}{1-\text{Nilai TPV pada Faktor } Cost\ (C)} \quad (6)$$

A project is said to be feasible or can be implemented if the ratio of benefits to costs required is greater than one. The approach to using B / C Analysis in ANP is the same as the B / C Analysis approach in general, if the ANP comparison will be made is superiority priority and price priority, so that what will be chosen is the comparison value with the largest value.

3. DATA COLLECTION AND PROCESSING

This section will explain about data collection, which then the results will be processed to get the desired results.

3.1 Procurement of Patrol ship types

The procurement of a KRI is a special procurement because it includes defense equipment which has a secret nature and cannot be carried out by incompetent parties. The procurement process was not easy, involving many teams overseeing the process, from the negotiation and insurance supervisory team, the task force team, the feasibility team, the function test team or acceptance test, the inspection team to the receiving team.

In the Indonesian Navy, the procurement of a KRI is regulated in the Decree of the Chief of Naval Staff No. Kep / 1100 / VI / 2015, which is contained in the PUM-7,100 of the Indonesian Navy regarding the Guidebook for the Implementation of the Procurement Determination Board (Wantuada) of the Indonesian Navy's Alut and Alutsista. Therefore, in determining the KRI to be purchased, it must be based on the basic function of the KRI, it is faced with the task field at hand, so it is necessary to determine various appropriate criteria.

3.2 Data collection

Before processing data, it is necessary to first collect the required data. The data to be obtained based on the method of collection can be divided into primary data and secondary data. Primary data is obtained directly from resource persons who are experts in their fields and someone who is a decision maker by filling out questionnaires and face-to-face interviews. While secondary data is data obtained through literature studies both from documents and related reference books. The desired data includes various factors that influence the decision in choosing the type of patrol boat, including technical specifications, characteristics of the ship material used, operation and maintenance, the state of the country's economy.

3.3 Patrol Ship Type Selection Criteria

Criteria are measures, rules, and standards that are used by decision makers. Various factors are considered in the decision-making process for choosing which type of patrol boat to purchase in the future. At this stage, the determination of criteria is carried out preceded by conducting consultations with shipping experts. Consultation is carried out by

means of discussion, either carried out with an expert or discussion with several experts in the fields of operations, technicians, maintenance, procurement and research and development offices.

The criteria developed are related to the factors that influence the decision to choose the type of patrol boat that will be considered for future development of the Satrol Boat. Taking into account the opinions of various sources both from the Navy shipping experts and their users as well as the existing literature, in this study the following criteria were developed. The criteria considered for selecting the right patrol boat at a base are divided into two parts, namely quantitative criteria and qualitative criteria.

3.3.1 Quantitative Criteria

Quantitative criteria are criteria that have a definite value, so that they can be compared between one choice and another. As for the quantitative criteria that are taken into consideration in the selection of this patrol boat are as follows:

a. Procurement and Operational Costs
b. Speed
c. Use age
d. Range / Mileage

3.3.2 Qualitative Criteria

Qualitative criteria are criteria that do not have a definite value, so to find out the value it is necessary to quantify the qualitative criteria and then obtain a numerical value from the qualitative criteria. As for the quantitative criteria that are used considerations in selecting weapons are as follows:

a. Reliability
b. Maintainability
    1) Field Maintenance
    2) Ease of Spare Parts
c. Complexity
    1) Safety Features
    2) TOT
    3) Service
d. Operation
    1) Ease of Use
    2) Operating Personnel
e. Tactical
    1) Navigation
    2) Platform
    3) Sewaco
    4) Machinery
    5) Electrical
f. Special
    1) Political
    2) Strategic

3.4 Alternative Patrol Ship

The alternative of selecting the type of patrol boat used in this study is a suitable type of Satrol Boat in Lantamal, which will be developed for the future. The types of patrol boats include:

a. “A” Class ships;
b. “B” Class ships; and
c. “C” Class ship.

3.5 Data processing and analysis

At this stage, data processing will be carried out on the data obtained in the previous sub-chapter. The aim is to obtain a more detailed description of the relationship between each criterion, alternative types of patrol boats and the general procurement process with the help of software in the calculation process.

3.5.1 Fuzzy MCDM processing method Analysis of the total aggregate weighting results

In the aggregate weighting process for data for each criterion and alternative, data processing is carried out with the aim of finding the lower, middle and upper values for each criterion and alternative.

The following is a recap of the criteria and alternative weights generated using the fuzzy MCDM calculation shown in Tables (4.1) and (4.2).

The recap of weights shown in table (4.1) is only the middle value of each criterion and likewise the alternative weight values shown in the table are only the middle value.

Table 1. Recap of the Aggregate Weights of Qualitative Criteria

NO	QUALITATIVE CRITERIA		WEIGHT
1.	RELIABILITY		8,4
2.	MANTAINABILITY	MAINTENANCE	6.37
		EASY SUCAD	8,1567
3.	COMPLEXITY	SAFETY FEATRS	6,885
		TOT	6,7317
		SERVICE	6,0667
4.	OPERATION	EASY TO USE	6,5117
		PERSONNEL OPS	6,3583
5.	TACTICAL	NAVIGATION	9,3033
		PLATFORM	9,3033
		SEWACO	5,8383
		MACHINE	6.8067
		ELECTRICAL	6,6733
6.	SPECIAL	POLITICAL	5,9083
		STRATEGIC	6,7433

Table 2. Recap of Alternative Aggregate Weights

NO	CRITERIA	Mit	Weight
1.	Reliability	ALT 1	7,812
		ALT 2	7,765
		ALT 3	6.95
2.	Maintainability	ALT 1	6,623
		ALT 2	6,603
		ALT 3	7,812
3.	Complexity	ALT 1	6,072
		ALT 2	6,333
		ALT 3	9,072
4.	*Operation*	ALT 1	6,945
		ALT 2	8,038
		ALT 3	7,535
5.	Tactical	ALT 1	6,962
		ALT 2	7.49
		ALT 3	8,043
6.	Special	ALT 1	6,617
		ALT 2	7,475
		ALT 3	7.78

Tables (4.1) and (4.2) are the aggregate total weighting results where this weighting is useful for finding the fuzzy index and will be used as data input for the defuzzification process.

3.5.2 Analysis of the fuzzification and defuzzification processes

Defuzzification is a process to get a single value from the linguistic value. The best defuzzification method to use in fuzzy MCDM is the Center of Gravity (COG) method / Centroid method (Kainz, 2003). By paying attention to this research, in this research the researcher uses the Centroid method by taking the Crisp value (single value) that comes from the middle of the existing fuzzy area so that it is very precise with the design of the membership function and the basis of the fuzzy rules used.

Table 3. The index value forming the evaluation value

INDEX	ALTERNATIVE		
	1	2	3
Yi	20.81	22.37	25.95
Qi	47.87	49.76	54.86
Zi	74.13	76.16	80.93
Hi1	1,827	2,167	2,458
Ti1	6,014	5,318	5,106
Hi2	5,208	5,433	5,898
Ui1	2.68	2,595	2,286
Ti2	21.98	23.05	25.1
Ui2	-27.9	-28.2	-27

After knowing the index forming the evaluation value in table (4.4), then the process of searching for the value of the fuzzy membership function (fG (x)) and the fuzzy Gi index is carried out followed by processing it into a utility value so that it can be seen which alternative is the best. The following values for fGi (x) and Gi are shown in table (4.5).

Table 4. Value of fGi (x) and Gi

SCORE	Alt 1	Alt 2	Alt 3
Gi	45,100	47,172	51,961
FGI (x)	0834	0.895	0.988

After knowing the fuzzy index value, the next step is to find the utility value for each alternative based on qualitative criteria. By using the equation, the results of the utility value can be seen in the following table:

Table 5. Sti (Qualitative) Value for each Alternative

SCORE	Alt 1	Alt 2	Alt 3
Sti	0.230	0.247	0.272

Likewise for quantitative criteria, the utility value is also sought using the equation, it will get the utility value for the quantitative criteria which we can see in the table below:

Table 6. The OTi (Quantitative) Value of each Alternative

SCORE	Alt 1	Alt 2	Alt 3
OTi	0.234	0.247	0.281

From (Table 4.7) above it can be seen the utility value of each alternative. From the 3 alternatives, it can be seen that alternative 3 has the highest utility value, namely0.281 followed by alternative 2 of 0.247, and the last alternative 1, namely 0.234.

Finally, to get the total ranking value for each alternative, both qualitative and quantitative criteria, use the above equation so that the final result can be seen in table (4.8) below:

Table 7. Total score and final ranking of each Alternative

VALUE	Alt 1	Alt 2	Alt 3
FTi	0.232	0.347	0.421
RANK	III	II	I

3.5.3 Processing of the analysis method of Benefit Cost Analysis (BCA)

Another theory used by researchers in data processing in this study is Benefit Cost Analysis (BCA). The technique chosen for data processing using the BCA theory this time is the Benefit Cost Ratio (BCR) technique which will produce the BCR value. If the comparison result of BCR> 1 means that the project provides benefits if BCR <1, then on the other hand, the project is detrimental or does not provide benefits.

In this study, classify all the existing criteria in determining the types of elements of the Satrol Lantamal V, which amount to 19 sub-criteria, into two groups of factors, namely the Benefit factor and the Cost factor. Benefit factors are defined as all factors that can have a positive influence and good results on the selection of elements of Satrol Lantamal V. While the cost factor is anything that requires more cost, time and energy to fulfill it, so that it can support the operational elements of Satrol properly. The results of the weighting value of each alternative of the Benefit factor will be compared with the result of the Cost factor, so that the weight of the benefits or benefits of each of the available Satrol element alternatives will be known.

Table 8. Classification of Benefit and Cost Factors

NO	CRITERIA	GROUP
1	RELIABILITY	Benefits
2	PLEASE	Cost
3	EASY SUCAD	Cost
4	SAFETY FEATURES	Benefits
5	TOT	Benefits
6	SERVICE	Cost
7	EASY TO USE	Benefits
8	PERSONNEL OPERATING	Benefits
9	NAVIGATION	Benefits
10	PLATFORM	Benefits
11	SEWACO	Benefits
12	MACHINE	Benefits
13	ELECTRICAL	Benefits
14	POLITICAL	Cost
15	STRATEGIC	Cost
16	PROCUREMENT AND OPS	Cost
17	ENDURANCE	Cost
18	SPEED	Cost
19	AGE OF USE	Cost

The priority weight results show the overall priority of alternatives and existing criteria, both on the benefit and cost factors. In the end, the Total Priority Value (TPV) for the Cost Factor and Benefit Factor of each of the Surabaya Lantamal V Surabaya Satrol Vessels is as follows:

Table 9. The Priority Weighted Value of Benefit and Cost Factors

NO	TYPE OF SHIP	TOTAL PRIORITY VALUE	
		BENEFIT	COST
1	"A" Class	0.09685	0.11509
2	"B" Class	0.05577	0.06313
3	"C" Class	0.30658	0.28283

After entering into the BCR formula, it is obtained:

- BCR Value of Satrol "A" Class = 0.15
- BCR Value of Satrol "B" Class = 0.24

- BCR Value Satrol "C" Class = 1.03

The BCA calculation is obtained through the BCR technique which compares the TPV value of the results of grouping the criteria for selecting elements of Satrol Lantamal V Surabaya into the Benefit and Cost Factors. The results of the Satrol "C" Class element can provide benefits or benefits (BCR value 1.03). Meanwhile, other Satrol elements did not provide benefits / advantages (BCR value <1).

4. CONCLUSIONS

This chapter contains the conclusions from the results of the research that has been carried out and suggestions that can be given to the Indonesian Navy as well as for the development of further research. From the stages of data processing and analysis carried out in the previous chapter, the following conclusions can be drawn:

a. There are 6 (six) main criteria with 15 (fifteen) sub-criteria on the qualitative criteria and 4 (four) quantitative criteria used to determine the priority of the 3 (three) alternative Satrol ships to be operated in Lantamal V Surabaya.

b. Based on data processing with Fuzzy MCDM, the alternative was selected with the highest weight of "C" Class with a value of 0.421 and based on BCR analysis the selected "C" Class was also selected because based on the results of data processing it had the highest BCR value of 1.03 meaning it was the most profitable when choosing the ship. Thus, it can be used as a reference for the leadership of the Indonesian Navy in determining policies for selecting priority types of Satrol ships.

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