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## THE MODEL FOR DETERMINING LOCATION OF NAVAL BASE USING AHP METHOD AND SET COVERING PROBLEM

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### ABSTRACT

Indonesia is a nation that has a lot of island with most of its territory (2/3) is the sea and the rest of it (1/3) island that consist of many islands, this kind of geographical condition insist Indonesian Government control and guaranty its sea security following the United Nation Convention on the Law on the Sea (UNCLOS) 1982. Bear in mind that Indonesia is an archipelago state with 17.499 islands and 5,8 million km<sup>2</sup> sea territory with the geographical situation as the cross-section between two continents and two ocean, bring trough vulnerability at sea for instance territory trespassing, sea exploitation, smuggling, piracy and sabotage. Indonesian Navy Base as one of SSAT component is a main supporting force in sea combat operation, especially for maintain WARSHIPS mobility. The Indonesian Navy's role as a place that develops deployment forces position will have an important meaning in safeguard Indonesian domestic sea security. Also, the Naval Base as a "Home Base" has a five criterion of function following the 5R, that is Rest, Refresh, Refuel, Repair and Replacement so that the Naval Base will provide a very significant role for the success of the support of the Navy's operations. In the tactics of the operation currently carried out as a policy of operating degree efficiency, the tactics of waiting are carried out with the Navy Base as an Indonesian Naval Warship waiting point. So that following the function and location of the position, the naval Homebase is a strategic component in carrying out the maintenance and care functions of materials and personnel and can give support for the speed of motion reaction of Indonesian Naval Warship acting elements to get to the position of events at sea. The choice of the Naval Base location is a decision-making process with many MCDM criteria (Multi-Criteria Decision Making). The complexity of variables and the dependency relationships between variables in the system, as well as the subjectivity of decision-makers can cause uncertainty. In this paper, a model using a combination of Analytical Hierarchy Process (AHP) methods and Set Covering Problem methods will be made that can assist the process of determining the location of the Indonesian Naval Warship Base in carrying out its duties to secure the territorial sea of the Republic of Indonesia.

### KEY WORDS

Indonesian naval base, indonesian naval warship, analytical hierarchy process, set covering problem.

The Unitary State of the Republic of Indonesia is a country that has an archipelago with an area of which most (2/3) are sea areas and the rest (1/3) is the area consisting of land which is grouped with islands so that consequently Indonesia must be able to control and securing all of its ocean areas following the provisions of the 1982 United Nations Convention on the Law on the Sea (UNCLOS) (Subroto, 1983). Considering Indonesia is an archipelago with 17,499 islands and sea area reaching 5.8 million kilometers and cross position which is located between two continents and two oceans, it is possible to create vulnerabilities such as territorial violations, illegal extraction of marine wealth, smuggling, piracy and sabotage (Hamzah, 1984).

As a component of national defense at sea, the Navy is tasked with implementing a national defense policy that is to defend national sovereignty and territorial integrity, protect the honor and safety of the nation, carry out military operations other than war and participate actively in the task of maintaining regional and international peace. In the effort to carry out national defense at sea, the Navy carries out tasks that are manifestations of the

three universal roles of the Navy, namely the military role, the role of the police, and the role of diplomacy (Indonesian Navy Headquarters, 2005).

The Indonesian Navy divides the command work area into 3 (three) Main Command areas with 14 Navy Main Base. Republic of Indonesia Fleet Command I with Command center in Jakarta, Republic of Indonesia Fleet Command II with Command center in Surabaya and Republic of Indonesia Fleet Command III with Command center in Sorong, as shown in figure 1. Indonesian Navy Base as an integral component of SSAT is the spearhead of the force in carrying out support for the naval combat operation task especially as a support for the movement of the warships operations task. The role of the Navy as a place to develop sea power into the area of operation or "deployment forces position" will have an important meaning in supporting the operational tasks of the Navy as an operational unit for internal security at sea. Besides, the Navy Base as a "Home Base" has a criterion of function following the 5Rs, namely: Rest, Refresh, Refuel, Repair and Replacement so that the Navy Base will provide a very significant role for the successful support of the Navy's operational title. In the operation tactics currently carried out as a degree of efficiency policy for operations, the tactic of waiting is carried out with the Navy Base as a WARSHIPS waiting point. So that under the function and location of the position, the base is a strategic component in carrying out the maintenance and care functions of materials and personnel and can provide support for the speed of reaction of the WARSHIPS action elements to get to the position of events at sea.

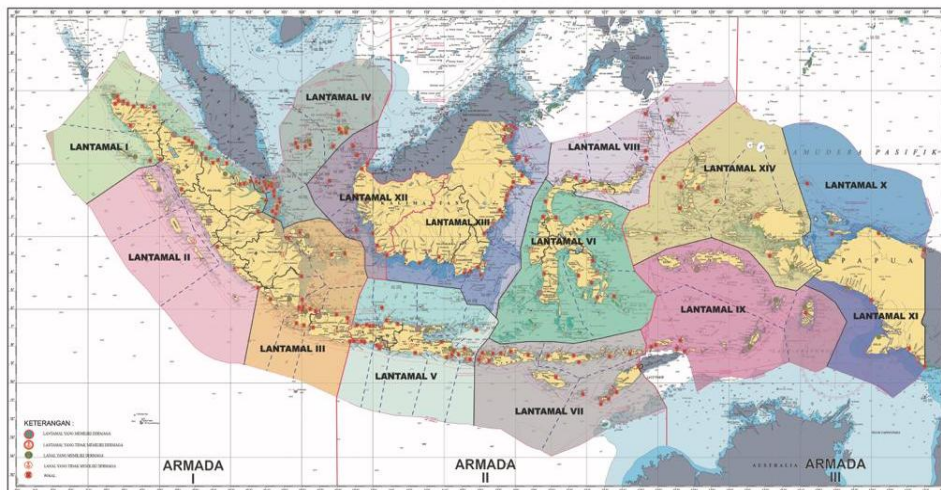


Figure 1 – Map of the Republic of Indonesia Fleet Command Work Areas I, II and III

Considering the large number of criteria used in determining the location of the Navy base and the limited state defense budget conditions and the limited WARSHIPS roaming capability, there must be a priority in efforts to develop the base so that it can contribute directly to the title of the Navy's operations. During this time in determining the location of the Navy Base is only based on the results of the decision of the working group team (Pokja) formed by Kasal Planning Staff (Srena) Headquarters of the Navy. The Working Group formed by Srena Mabelsal reviewed the manuscript sent by the Base Team to be developed or upgraded. Then a qualitative brainstorming was carried out and sometimes elements of subjectivity included in the Pokja team. The complexity of the problems faced in the selection of the development of the Navy base, it is necessary to study and explore deeper data to create a representative model. This model must certainly be able to accommodate the entire scope of problems in developing bases, so this model is expected to be able to choose which bases are optimum and feasible to develop.

The choice of the Navy Base location is a decision making process with many MCDM (Multi-Criteria Decision Making) criteria, which is a multi-choice method that involves elements of objectivity and subjectivity criteria, also involving data/variables that are qualitative and quantitative. The complexity of variables and the dependency relationship

between variables in the system, as well as the subjectivity of decision-makers can cause uncertainty.

In this study, a model using a combination method, namely the Analytical Hierarchy Process (AHP) method and the Set Covering Problem method, can be used in the process of determining the location of the Indonesian Navy Base. With the determination of the exact location of the Navy Base, it will be able to support the operational tasks of the WARSHIPS as well as optimize the allocation of funds for WARSHIPS operational costs annually and optimize the area covered by the warships for safekeeping (Coverage Area) and optimize the patrol distance traveled by warships.

## **MATERIALS AND METHODS OF RESEARCH**

The world is a complex system and various interacting elements. For example, the economy will depend on the availability of energy and other resources, the availability of energy will depend on geography and politics, politics will depend on strength. military, while the military power itself in the modern era depends on technology, technology is only born of ideas (ideas), and the availability of resources, ideas need politics to get support. Thus this system will complexly show various interactions among its elements. In a complex network with various factors. where the initial and final causes cannot be identified easily, most people will think that life is so complex, so to solve a problem must be with complex thinking too.

Thinking in simple terms is difficult and solving complex problems with a variety of factors. In this condition what is needed is not a complicated way of thinking, because simple turns are difficult enough. An issue needs to be viewed in an organized but complex form, where there are interdependencies and relations between factors, but it is possible to think of these factors simply. The source of the complexity of the problem to make a decision is not only the uncertainty, or imperfect information. Another cause is the number of factors that influence the choices available, the variety of selection criteria if the alternative decision is more than one. Decision analysis so far has specialized in the complexity of decision making because of imperfect information. The source of complexity in the problem of decision making biases in the form of information uncertainty and the number of criteria that influence. If the source of this complexity is the variety of criteria, then AHP is a technique to assist in solving the complicated problem. AHP is a flexible model and provides an opportunity for individuals or groups to develop ideas, and define the problem by making their respective assumptions and obtaining the desired solution from it. The AHP method was introduced by Thomas L. Saaty in 1971-1975 while at the Wharton School.

Sri Mulyono (1996) explained that the Analytic Hierarchy Process offers a solution to decision problems involving all sources of complexity, this is possible because the AHP relies sufficiently on intuition as its main input, but intuition must come from decision making that is sufficiently informed and understands the decision problems faced.

Saaty (1991) explains three basic principles of AHP:

- a. Describe and describe in a hierarchy called hierarchical arrangement, i.e. dividing the problem into separate elements;
- b. Differentiation of priorities and stenosis, called priority setting, is determining the level of elements according to their relative importance;
- c. Logical consistency, that is, ensures that all elements are logically grouped and ranked consistently according to a logical criterion;

Next Saaty explained some of the advantages of using AHP as an analysis tool like in Figure 2 are as follows:

- a. Unity: AHP provides a single model that is easy to understand, flexible for a variety of unstructured problems;
- b. Complexity: AHP combines deductive and system-based approaches in solving problems;
- c. Arrangement of Hierarchy: AHP reflects the natural tendency of the mind to sort out the elements of a system at various levels and group similar elements at each level;

- d. Consistency: AHP tracks the logical consistency of the considerations used in setting priorities;
- e. Synthesis: AHP leads to a comprehensive assessment of the merits of each alternative;
- f. Assessment and consensus: AHP does not force consensus but synthesizes a representative outcome from different assessments;
- g. Repetition of processes: AHP allows people to refine their definition of a problem and improve their consideration and understanding through repetition;
- h. Bargaining: AHP considers the relative priorities of various system factors and allows people to choose the best alternative based on their goals.

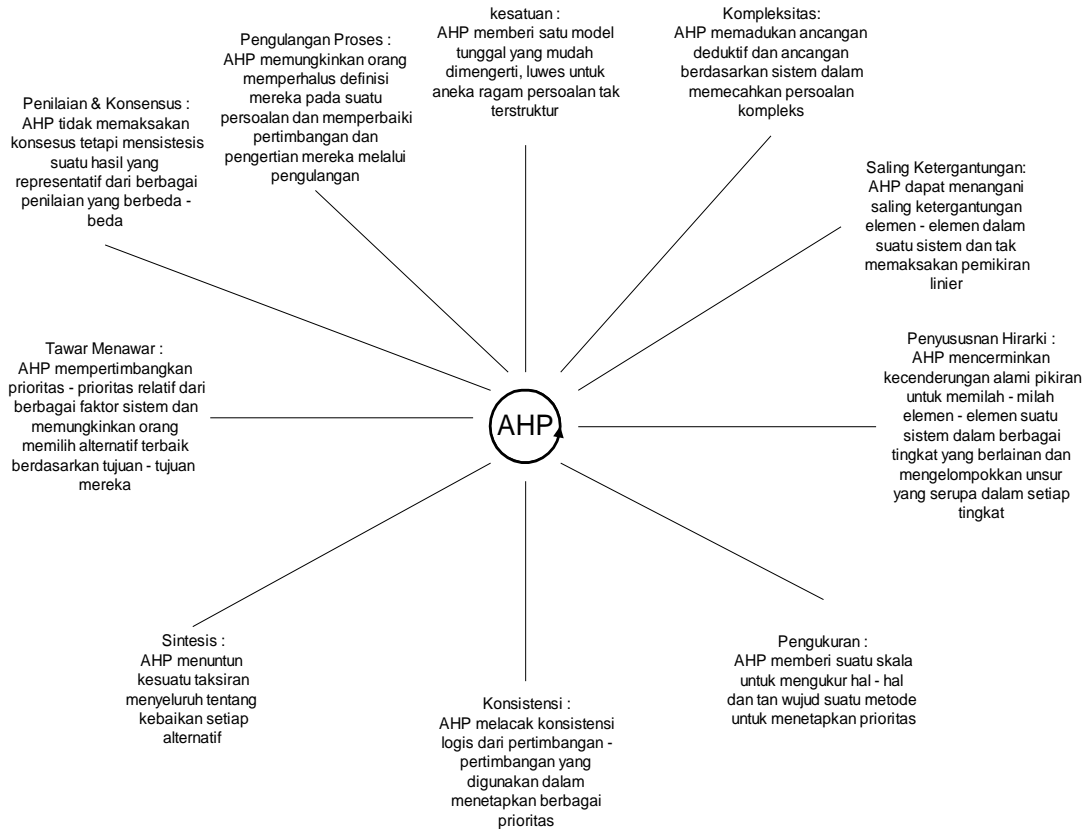


Figure 2 – Various advantages of AHP

The concept of Set Covering Methods is aimed at minimizing the number of hub ports/bases needed to service/cover other bases. The selected base will provide cover/service to the ship against other bases. So that it will minimize the number of hub ports/bases which will ultimately save the budget because the chosen base will be developed as the main base supporting marine security operations.

According to Heragu (1997), set covering appears in a system that has a requirement that every consumer can be reached by at least one facility. Meanwhile, according to Daskin (1995), set covering is a way to determine the lowest cost of the placement of several facilities where each demand node can be reached by at least one facility. From the two definitions above, in general set covering can be interpreted as the choice of location of alternatives that exist intending to minimize all the factors that influence with the limitation that each demand can be reached by the selected location.

Set Covering is one part of the allocation location problem. The purpose of the allocation location model is to determine the location of facilities that can minimize the cost of assigning facilities to customers with restrictions that each facility is used for a specified

number of customers. The service to the customer from the facility to be placed depends on the distance between the customer and the facility that will be assigned to the customer service can be done by the facility if the customer is within the specified distance and the facility is deemed incapable if the distance exceeds the critical value of the distance range.

An area is called within the coverage area if the area is located within range. Determination of distance is very important to consider in the application of the set covering method because it is the most influential factor in the optimal solution produced. The problem of set covering is to place the facilities in the minimum amount needed to cover all demand locations or if in this study select and place TNI AL bases in the number planned to cover the defense sector and sea security.

The parameters used in the set covering model are the distance of the location of the operating sector and the location of the Navy base which is formulated to plan the number of bases, as follows:

$$\begin{aligned} \text{Minimize} \quad & \sum_{j \in J}^n x_j \\ \text{Subject to} \quad & \sum_{j \in N_i}^n x_j \geq 1 \quad \forall i \in I \\ & x_i \in \{0,1\} \quad \forall j \in J \end{aligned}$$

The objective function (1) is to minimize the number of bases ( $x_j$ ) placed. Limiting function (2) guarantees that each sector is covered by at least one base. Decision variable (3) is a decision "Yes" or "No" a base is chosen as a cover at other bases in the sector.

## RESULTS AND DISCUSSION

Scientific research is a systematic framework so that it can facilitate the implementation of research later. The research framework must be prepared appropriately and directed based on the problem being reviewed. With this research framework, it is expected that the process and the results obtained will be under the desired objectives. For more details, the research methodology is shown in Figure 3.

Modeling is an activity to model problems to become more systematic, easy to understand, and easy to solve. Broadly speaking, the formulation of the model in this study is to develop theories and concepts of the AHP method.

### a. Application of the AHP Method

At this stage, the AHP method is implemented to find out bases that meet the criteria to be developed into Navy Base. The application of the AHP method in this study is calculated by entering the data obtained from the results of the questionnaire into the Expert Choice software. The steps taken in applying the AHP method are as follows:

#### 1) Identification of Research Variables.

In determining research variables, it must consider all information and criteria that can affect performance. Characteristics and criteria for selection of problems and data can all be referred to as research variables. This activity is carried out through interviews with relevant officials/staff that have competence with base development issues. It was also carried out by studying references in the form of appreciation and conception about the development of bases as well as references about the Standardization of the Navy Base.

In this activity, problem solving and breakdown are carried out into small components. The results of this activity are elements from the criteria to the alternatives that will be selected as decisions. Furthermore, these elements are arranged in levels that constitute a hierarchy for decision making.

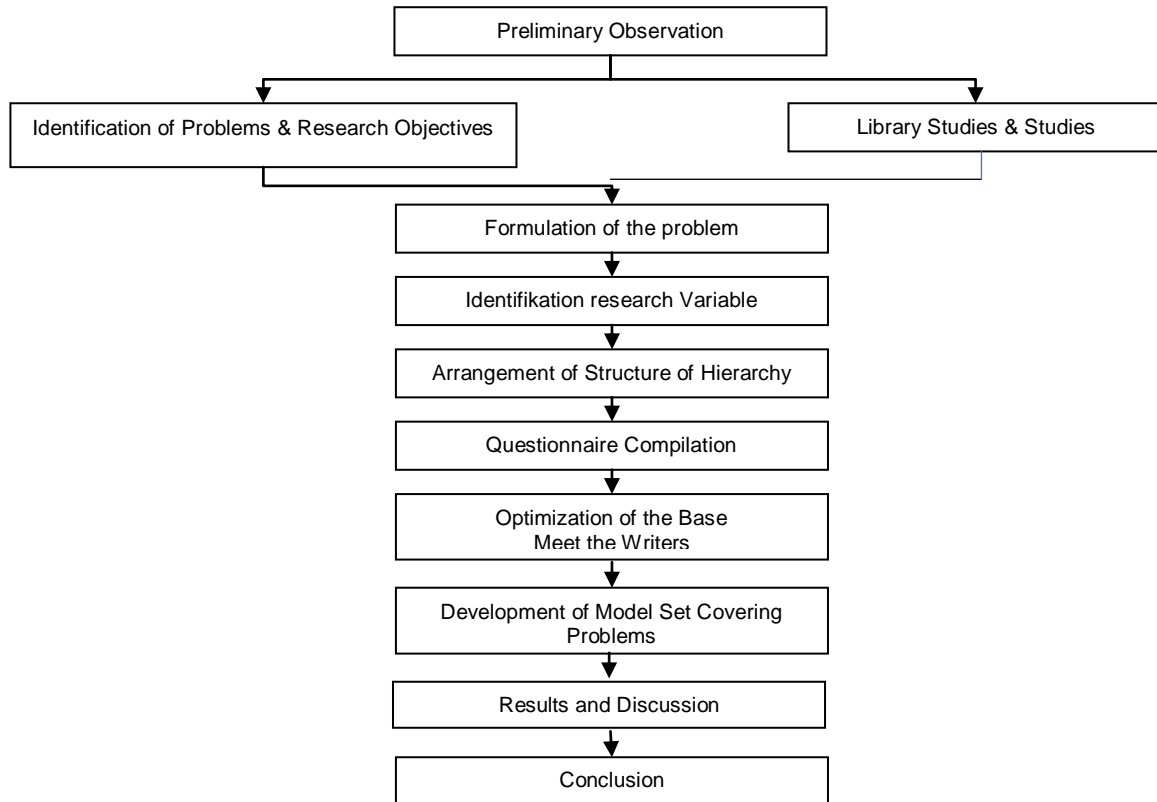


Figure 3 – Methods of Research

## 2) Compilation of Hierarchical Structures.

The components of the problem of the decomposition results are then arranged in a hierarchy. The top hierarchy is the focus or goal to be achieved, along with the criteria which are the determining factors in the determination process. Furthermore, downgraded again into smaller parts as sub-criteria and sub-criteria. While the hierarchy at the lowest level is alternatives to the Indonesian Navy base which will be analyzed based on the above factors. Like in picture 4.

For the composition of the hierarchy that is formed consists of 4 levels, namely:

a) Level 1: Is the focus of the goal to be achieved, which is to determine the priority of developing naval bases in the work area of Koarmada II;

b) Level 2: Identified criteria elements will contribute to the goal of developing the base. These elements are based on the results of a literature study on the Indonesian Navy Base and interviews with experts who are competent on this issue, especially officials/staff concerned;

c) Level 3: These are the elements of the sub-criteria identified to form the criteria element. These elements are also obtained from the results of literature studies on the Navy Base and interviews such as at level 2. While at some elements of this level namely, Binpotnaskuatmar, Bintermatla, and Environmental Conditions will be directly confronted with various alternatives, namely the Navy Base at Koarmada II working area;

d) Level 4: Are elements that are directly related to alternatives to the Indonesian Navy Base in the work area of Koarmada II.

## 3) Preparation of the Questionnaire.

Data collection for the AHP method can be done by throwing questionnaires to obtain several quantitative decision considerations following the hierarchical model, which is an element of the contents of the paired comparison matrix, where the comparison is done in pairs between variables at each level of the hierarchy. The results of the comparison are stated quantitatively following the specified measurement scale. As in table 1 and table 2.

Table 1 – The Navy Base Selection Questionnaire based on Pairwise Comparative Matrix at Level 2

Basic Tasks & Base Functions	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	General Conditions	Base
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Table 2 – Indonesian Navy Base Selection Questionnaire based on the Pair Comparative Matrix at Level 3 for Basic Tasks and Base Functions

Operational Unit Support	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sea Security
Operational Unit Support	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sea Territorial
Operational Unit Support	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sea Strength Potential
Sea Security	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sea Territorial
Sea Security	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sea Strength Potential
Sea Territorial	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sea Strength Potential

At this stage, the model development is carried out by entering the data that has been obtained in the form of distance data of the WARSHIPS range and the weight of the Navy Base values which become a choice of results from the AHP method. The application of the set covering model uses the help of the Excel solver program.

The problem of set covering is how to place the bases in the minimum amount needed to cover all existing patrol sectors. The optimal base allocation is that it can cover all the patrol sectors in the Koarmada II region. The condition to be achieved is to obtain a minimum number of appropriate naval bases by maximizing the range of the WARSHIPS used to carry out patrol duties.

The formulation of the Set Covering Problem model used is as follows:

a. Decision Variable.

The basic form of the decision variable is  $X_{ij}$  which means WARSHIPS from the  $i$ -th base, assigned to the  $j$ -th Patrol Sector, and back to the  $i$ -th Base; with  $i$  = base start and end,  $j$  = Patrol sector; where:  $X_{ij} = 1$ , if warships are assigned from Base  $i$  to the Patrol Sector  $j$ ;  $X_{ij} = 0$ , if warships is not assigned from Base  $i$  to the Patrol Sector  $j$ .

b. Objective Function.

1) Maximizing the weight of the Navy Base:

$$\text{Max } Z = \sum_i^n \sum_j^n C_{ij} X_{ij}$$

Where: Max  $Z$  = Maximizing the weight of the Navy Base;  $C_{ij}$  = AHP weight value from each Base  $i$  to the Patrol Sector  $j$ ;  $X_{ij}$  = WARSHIPS assigned from Base  $i$  to the Patrol Sector  $j$ .

2) Maximizing coverage of Indonesian Navy Base:

$$\text{Max } Z = \sum_i^n \sum_j^n D_{ij} X_{ij}$$

Where: Max  $Z$  = Maximizing coverage of Indonesian Navy Base;  $D_{ij}$  = Distance coverage from each Base  $i$  to the Patrol Sector  $j$ ;  $X_{ij}$  = Warships assigned from Base  $i$  to the Patrol Sector  $j$ .

c. Constrains Function. There are two constraints to this problem, namely:

1) First Constraint Function:

$$\sum_i^n \sum_j^n D_{ij} X_{ij} \leq R$$

Where:  $D_{ij}$   $X_{ij}$  = Distance range from Base  $i$  to  $j$ -patrol sector;  $R$  = Range of WARSHIPS reach.

2) Second Constraint Function:

$$X_{ij} \geq 1$$

$X_{ij}$  = WARSHIPS assigned from Base  $i$  to the Patrol Sector

## CONCLUSION

AHP model that has been made can be used to determine the location of a Navy Base based on the criteria that have been made in the AHP hierarchical structure model, namely:

1) Level 1:

Focus: Determining the location of the Indonesian Navy Base.

2) Level 2:

Criterion 1: Main Duties and Base Functions;

Criterion 2: Base General Conditions.

3) Level 3:

Sub Criteria 1: Operational Unit Support;

Sub Criteria 2: Sea Security;

Sub Criteria 3: Sea Territorial;

Sub Criteria 4: Sea Strength Potential;

Sub Criteria 5: Environmental Conditions.

4) Level 4:

Sub Criteria 1: Facility 1;

Criterion 2: Facility 2;

Criterion 3: Facility 3;

Criterion 4: Facility 4;

Criterion 5: Facility 5;

Criterion 6: Geographical Conditions;

Sub Criteria 7: Condition of Sumda;

Sub-criterion 8: Social Conditions;

Sub Criteria 9: Climate and Weather;

Sub-Criterion 10: Ship Dispersion, Aircraft, Pasmara;

Sub Criteria 11: SSAT Component Readiness;

Sub Criteria 12: Benefit Friend and Difficult Opponent;

Sub Criteria C 13: Defense and Protection;

Sub Criteria 14: Facilities following Operational Requirements.

Set Covering Problem Optimization Model. that has been made can be used to determine the location of a Navy Base. The data needed to operate the Set Covering Problem Optimization model include:

1) Data on the weight value of each Navy Base generated from the AHP model;

2) Patrolling Forces Data.

WARSHIPS grouping in 3 strengths namely Striking Forces, Patrolling Forces, and Support Forces is intended to smooth the priority scale in preparing ships according to the reality of combat functions in the field with support according to their respective functions. The Patrolling Forces group is prioritized on pushing systems, navigation equipment as well as the presence of operations at sea for the Kamla action (Kasal, 2005).

WARSHIPS elements included in the Patrol Forces group consisted of Parchim, Fast Patrol Boat (FPB), and Fast Patrol (PC) (Asops Kasal, 2004). WARSHIPS (Indonesian Navy patrol boat) has the following basic capabilities:

a) It is a means of sea patrol in charge of carrying out maritime surveillance and security;

b) Wartime can carry out protection operations against sea lines communication;

c) It can operate at sea in all sea weather conditions;

d) Have equipment that can classify targets, observation, and identification;



e) Equipped with a Weapon Control System (SKS) for self-defense against danger.

Patrol boat data is used to calculate the coverage capabilities of patrol vessels during sailing carrying out operations. Patrol ships that move from one point to another during operation have variable capability, speed, endurance, or endurance and radar coverage capabilities.

To calculate the coverage area of a patrol boat during sailing is described and formulated in Figure 5:

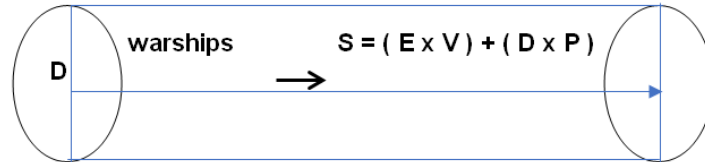


Figure 5 – The distance of Warships Coverage

The coverage area of the patrol boat is the area of the rectangle (L1) plus the area of the circle (L2) times the number of possible radar detections (taken at 0.9).

$$\text{Warships Coverage: } S = (E \times V) + (D \times P)$$

Where: E = Endurance (hours); V = Warships speed (Nil / hour); D = Radar Reach (Nil); P = Probability (0.9).

Table 1 – Warships Coverage Capability Data

No	Warships Code	V	E	D	R
1	UP	24	96	48	2347
2	NU	24	96	48	2347
3	LM	24	96	48	2347
4	SO	24	96	48	2347
5	WO	24	96	48	2347
6	MS	24	96	48	2347
7	TJ	24	96	48	2347
8	HB	24	96	48	2347
9	IB	24	96	48	2347
10	PD	27	120	48	3283
11	SA	27	120	48	3283
12	HU	27	120	48	3283
13	LY	27	120	48	3283
14	KP	27	120	48	3283
15	KU	27	120	48	3283
16	TK	27	120	48	3283
17	TD	27	120	48	3283
18	LD	27	120	48	3283
19	SP	29	72	48	2131
20	KT	29	72	48	2131
21	WK	29	72	48	2131
22	PN	29	72	48	2131
23	KL	29	72	48	2131
24	TN	29	72	48	2131
25	PT	29	72	48	2131
26	TW	29	72	48	2131
27	WL	29	72	48	2131

*Future Work.* Based on the conclusions from the results of the study, Future Work can be made as follows:

- a. The AHP model and the Set Covering Problem optimization model can be used to determine the location of the Navy Base in support of the warships patrol duty directly;
- b. Further research that can be suggested is to proceed with researching dynamic systems to see the sustainability of the Indonesian Navy Base.

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