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SELECTION OF KRI HARDEPO PRIORITIES USING THE FUZZY MCDM METHODS

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ABSTRACT

The Unitary State of the Republic of Indonesia (NKRI) is the largest archipelagic country in the world, two thirds of which are is seas, requiring the presence of the KRI in maintaining its sovereignty. Continuity of attendance in carrying out its main duties, the Navy depends on the readiness of the KRI (Indonesian Republic Warship). The Navy's strength development program is bound to the MEF (Minimum Essencial Force), the basic development policy of TNI AL towards minimum principal strength. The main target of MEF is a limited amount but can operate optimally. So we need a program to overcome these problems by maximizing the defense system maintenance program called SPT (Planned Maintenance System). To maximize the planned maintenance system that supports the MEF program requires prioritization in selecting the KRI that will carry out Depo level improvement (Hardepo). The selection of KRI determination that will implement Hardepo has several factors that need to be considered so that it is categorized in a multi-criteria decision environment, then the proposed model becomes an appropriate methodology to accommodate the criteria with the Fuzzy MCDM (Multi Criteria Decision Maker) approach. In this study there are six alternative KRI namely KRI Keris-624, KRI Rimau Island-726, KRI Kerapu-812, KRI Badau-841, KRI Jakarta Bay-541 and KRI Arun-903 where the first priorities obtained are KRI Rimau Island- 726 with a weight value of 0.1778. After the priority is obtained then schedule the duration and availability of Docking at PT PAL Indonesia where all KRI can carry out docking every TW (Tri Wulan) except KRI Arun-903 which cannot carry out docking on TW I 2019.

Keyword : MEF, SPT, Hardepo, Fuzzy MCDM, Docking Scheduling.

1. INTRODUCTION

The Republic of Indonesia (NKRI) is the largest archipelagic state in the world with ± 17,499 islands, with a national jurisdiction area of 7.8 million km2 and two-thirds of its territory is a sea of 5.8 million km2 and a coastline along the coastline ± 81,000 km.

In accordance with the Law of the Republic of Indonesia Number 34 Year 2004 concerning the Indonesian National Army, Article 9 states that the Navy duty are:

a. Carry out the duties of the TNI sea dimension in defense field.

b. Uphold the law and maintain security in the sea territories of national jurisdictions in accordance with the provisions of national law and international law which has been ratified.

c. Carry out Navy diplomacy in order to support foreign policy set by the government.

d. Carry out the tasks of the TNI in the development of the ses dimension strength.

e. Carry out the empowerment of marine defense areas.

In carrying out these basic tasks required SSAT (Integrated Fleet Weapon System) one of which is the KRI. Continuity of attendance in carrying out its main duties the Navy depends on the readiness of the main weaponry system (the main tool of the weapons system).

In this method approach, the development of the strength of the Navy is bound to the MEF (Minimum Essencial Force) as stipulated in the Kasal regulation No: Perkasal / 39 / V / 2009 concerning the basic development policy of the Navy towards a minimum basic strength. MEF is a force that is compiled based on the minimum capability needed to deal with all forms of threats in order to uphold sovereignty and maintain the integrity of the Unitary Republic of Indonesia with all risks faced. Thus the defense equipment preparedness is needed so that it can operate effectively when needed. The Navy's defense equipment readiness in this case is the KRI

(Indonesian Republic's Battleship) plays a large role in supporting the MEF program, bearing in mind the main target is a limited number but can operate optimally. To overcome this problem the Indonesian Navy conducted a defense equipment system called the SPT (Planned Maintenance System). SPT is a maintenance program that has been planned in advance so that a ship gets standard facilities for planning, scheduling, controlling, and conducting maintenance of all equipment throughout the life of the ship. One type of SPT activity is the Depot level maintenance activity (Hardepo) which is routinely carried out by the Navy in maintaining the defense equipment readiness.

Depo Level Maintenance is comprehensive maintenance that can only be carried out by personnel who are experts in their field and are supported by complete and sophisticated equipment and facilities. Maintenance at this level includes complete over houl repair, rebuilding (mid-life modernization), calibration of all equipment, and overall repair of all parts. Maintaining the Depo Level is to maintain technical conditions based on the clock. If the repair schedule specified in the SPT must be run. Depo Level Maintenance is carried out by a third party, while the characteristics of Depo level maintenance are::

a. Complex / large maintenance properties.
b. The time taken is too long.
c. Large costs required.
d. The quality of required personnel is high.
e. Spare parts are available at the Depo Material warehouse.
f. KRI age.
g. The need for attendance at sea.

For Depo Level Maintenance Organizations are Mabesal level material development organizations namely Dismatal guidance (Navy Material Office)

Hardepo activity is a maintenance activity that is cumulative in returning to the initial conditions of the clock / time period by the maintenance and repair facilities (Fasharkan), the national shipyard (Galkapnas), the maritime service industry (Injasmar) using the support of the Dopusbek On Board Spare (OBS) or procurement by the head of the activity organizer (Kalagiat). The activity is certainly not an easy thing because it deals with timeliness in scheduling, quality of repairs, accuracy and accuracy in material procurement and budget given by the government to the Navy, given the large number of KRIs and all defense equipment both on land and various other basic needs.

The current condition of the KRI Hardepo determination is carried out by direct appointment by the Disharkap (Ship Maintenance Agency) based on routine reports such as the Monthly Material Report (Labulmat) from the user / crewman in this case the ship members, so the results are not well targeted. The process of appointing Hardepo is still manually or not yet using empirical field data processing so that the results obtained are less than optimal.

Hardepo activities also require adequate facilities and infrastructure, docking facilities that support the implementation of hardepo vary according to the weight and length of the ship. Determination of docking locations and availability of docks also affect the implementation time, so that the implementation of activities can run on time.

With the development of the current era the determination and selection of ships that will carry out Hardepo can use various methods to get the best results. One of them uses the MCDM (Multi Criteria Decision Making) method. The fuzzy concept itself has been widely used as a model for building a decision support system, one of which is fuzzy MCDM. In various studies that, MCDM is a method that refers to the process of screening, prioritizing, ranking or choosing an alternative set. MCDM is very appropriate to be implemented in a multi-criteria case with all alternatives having criteria weights in the form of nominal / numbers.

2 LITERATURE REVIEW

2.1 Hardepo

Is a cumulative maintenance activity that returns to the initial conditions of the clock / time period by Fasharkan, Galkapnas, Injasmar using the support of OBS / Dopusbek or procurement from procurement by Kalagiat.

2.2 Fuzzy Theory

2.2.1 Definition of Fuzzy

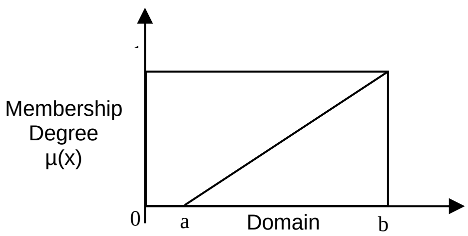
The concept of fuzzy theory was initiated by Lotfi A. Zadeh in 1965 with his seminal paper "Fuzzy Sets" (Zadeh, 1965). Before working with fuzzy theory, Zadeh used control theory. He developed the concept of "state", which is the basic form of modern control theory. With fuzzy theory shows that all theories can be used as a basic concept of fuzzy or continues membership function. Broadly speaking, fuzzy theory can be classified into five main areas, namely:

1. *Fuzzy Mathematics, where the concept of classical mathematics is expanded by changing the classical set with the fuzzy set*;
2. *Fuzzy Logic & Artificial Intelligence, where estimates for classical logic are introduced and expert systems are developed based on fuzzy information and thought estimates*;
3. *Fuzzy System, which includes fuzzy control and fuzzy approaches with signal processing and communication*;
4. *Uncertainty and Information, where differences from uncertainty are analyzed*;
5. *Fuzzy Decision Making, where consideration exists for optimization problems*.

2.2.2 *Fuzzy* Membership

The membership function (membership function) is a curve that shows the mapping of data input points into the value of membership (often also called the degree of membership) that has an interval between 0 to 1. One way that can be used to obtain membership values is through function approach. There are several functions that can be used:

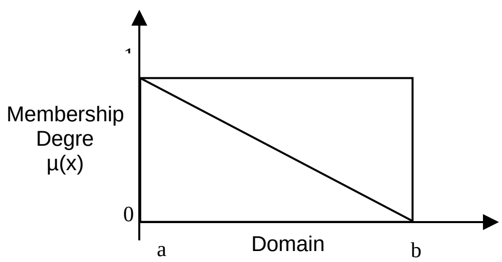
a. Represeniasi Linear



Gambar 4.2 Up Linier Representation

Membership Function:

$$\mu[x] = \begin{cases} 0; & x \le a \\ (x-a)/(b-a); & a \le x \le b \\ 1; & x \ge b \end{cases} \quad ..(2.3)$$

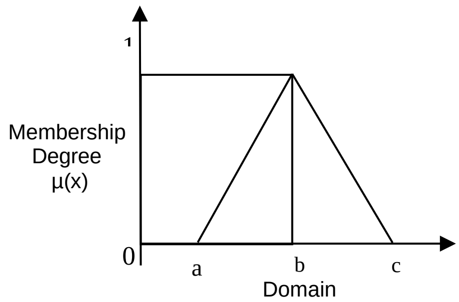


Gambar 4.3 Down Linier Representation

Membership Function:

$$\mu[x] = \begin{cases} (b-x)/(b-a); & a \le x \le b \\ 0; & x \ge b \end{cases} \quad ..(2.4)$$

b. Triangle Curve Representation

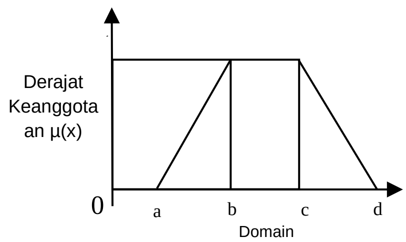


Gambar 4.1 Triangle Curve

Fungsi keanggotaan:

$$\mu[x] = \begin{cases} 0; & x \le a \text{ or } x \ge c \\ (x-a)/(b-a); & a \le x \le b \\ (c-x)/(c-b); & b \le x \le c \end{cases} \quad .. (2.5)$$

c. Representasi Kurva Trapesium



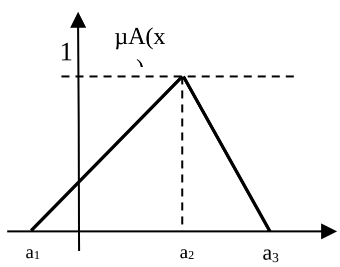
Gambar 4.4 Kurva Trapesium

Membership Function:

$$\mu[x] = \begin{cases} 0; & x \le a \text{ atau } x \ge d \\ (x-a)/(b-a); & a \le x \le b \\ 1; & b \le x \le c \\ (d-x)/(d-c); & c \le x \le d \end{cases}$$

2.2.3 *Triangular Fuzzy Number* (TFN)

In TFN, every single value (crisp) has a membership function consisting of three values, each of which represents the bottom value, middle value and top value. Graphically the membership function with TFN can be described as shown below:



Gambar 4.5 Triangular *Fuzzy* Number

$A = (a_1, a_2, a_3)$

The membership function for TFN in the picture above is as follows:

$$\mu[x] = \begin{cases} = 0 & \text{for } x < a_1 \\ = \frac{x - a_1}{a_2 - a_1} & \text{for } a_1 < x < a_2 \\ = \frac{a_3 - x}{a_3 - a_2} & \text{for } a_2 < x < a_3 \end{cases} \quad ....2.7$$

2.2.4 Defuzzifikasi of Values

Defuzzification is a process of conversion and a quantity of fuzzy into a definite quantity, where the output and the fuzzy process can be a combination of logic from two or more fuzzy membership functions that are defined according to the universe of speech. Defuzzy input and process is a fuzzy set obtained from the composition of fuzzy rules, while the resulting output is a number in the fuzzy set domain. There are several methods of defuzzification commonly used are as follows:

a. Metode Centroid (*Center Of Gravity/COG*)
b. Metode Bisektor
c. Metode *Mean of Maximum* (MOM)
d. Metode *Largest of Maximum* (LUM)
e. Metode *Smallest of Maximun* (SOM)

2.2.5 Linguistic variables

Linguistic variables are variables which have a description consisting of fuzzy numbers and more generally words represented by fuzzy sets. For example, descriptions of linguistic variables for temperature can be LOW, MEDIUM and HIGH where the description is expressed as a fuzzy value (fuzzy value). (Tsoukalas, 1997). Likewise, algebraic variables use numbers as values, while linguistic variables use valued words or sentences that form a set called "terms", each value of "terms" corresponds to the appropriate fuzzy variable based on the basic variables. While the basis variable for all fuzzy variables in the set of "terms" (Jantzen, 1998).

2.2.6 *Multiple Criteria Decision Making* (MCDM)

Multi-Criteria Decision Making (MCDM) is a decision making method that consists of theories, processes, and analytical methods for decision making that involve uncertainty, dynamics, and multi-criteria aspects of decision. Multi-Criteria Decision Making (MCDM) is the terminology used in solving problems where the MCDM approach is expected to get the best alternative.

2.3 *Critical Path Methods (CPM)*

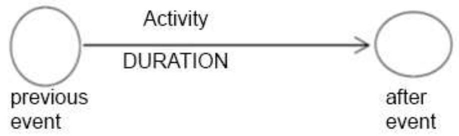
Critical Path Method (CPM) is the basis of a system of planning and controlling work progress based on a network. CPM was first used in the UK in the mid-50s on a power plant project, then was developed by the Intergrated Engineering Control Group of E.I du Pont de Nemours and Company initiated by Walker and Kelly jr. in 1957, both of them were from Reningtone Rand, Univac Computer Division, which was called Critical Path Schedulling (CPS) (Tarore2002).

(Heizer, & Render,, 2011) states that the Critical Path Method (CPM), is a Project Management Technique that uses only one time factor per activity. Meanwhile, According to Taylor III (2008: 333), said that a CPM network consists of branches and nodes that reflect the activity or a project or operation and nodes symbolize the beginning and end of an activity.

Critical Path Method (CPM) Is a project scheduling method that is well known and is often used as a management tool in implementing a "project". The network in a CPM scheduling consists of several types of activities that are interrelated with one another. If there is a delay in an activity, it often also causes a delay in the overall project duration.

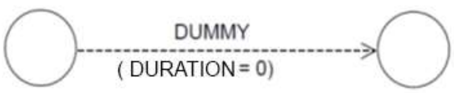
2.3.1 Activity in the Network CPM

The first step in the PERT or CPM network is to divide the entire project into significant activities, according to the work breakdown structure. There are two approaches to drawing project networks, namely activity on a point (activity on node-AON) and activity on an arrow (activity on arrow-AOA). The fundamental difference between AON and AOA is the point at AON diagram shows activity while the point on the AOA diagram shows the start time and the time when the completion of an activity called event. The AOA approach sometimes requires additional dummy activities to clarify the relationships and these activities have zero completion time.



Picture 2.7 Notasi Diagram

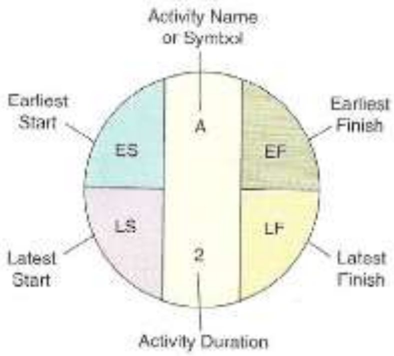
(Source : Sumardjito, Dasar penyusunan *Network* Planning 2011:2)



Gambar 2.8 Dummy Notation

(Source : Sumardjito, Dasar penyusunan *Network* Planning 2011:2)

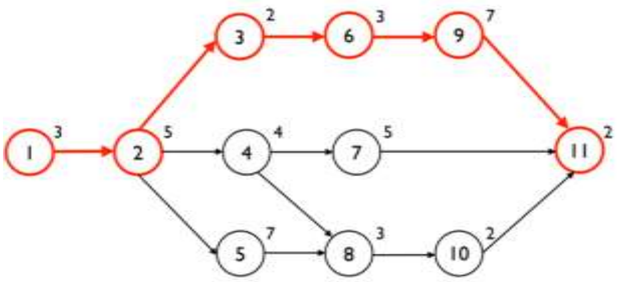
2.3.2 Steps for Making a Diagram



Gambar 4.6 Network Diagram

Work order requirements must be considered, because various activities cannot be started before other activities that can be carried out simultaneously and / or are not interdependent. Which activities must be completed before the next activity can begin. CPM recognizes several start and end times, among others:

a. *Earliest Start Time (ES) is the earliest (fastest) time for an activity to start, taking into account the expected activity time and the working order requirements*.



Gambar 4.7 Forward and Backward Pass notation

b. *Latest Start Time (LS) is the slowest time to be able to start an activity without delaying the entire project*.

c. *Earliest Finish Time (EF) is the earliest (fastest) time an activity can be completed, or equal to ES + expected activity time*.

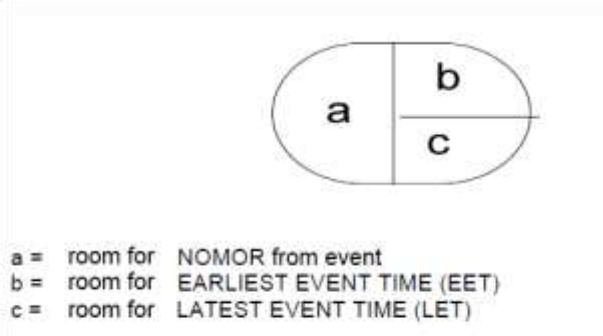
d. *Latest Finish Time (LF) is the slowest time to be able to complete an activity without delaying the completion of the overall project, or equal to the LS expected activity time. The following is an overview of the making of a Network project with the Critical Path Method given below*.

The process used to determine the time schedule for each activity is a two-pass consisting of a forward pass (ES and EF) and backward pass (LS and LF). Forward passes and backward passes use notation to show activity schedules on the project network clearly shown in the figure

(Source: Heizer dan Render,2009:99)

e. Determination of Event Times

In a network usually planners cannot say exactly when an event will occur. What can be stated is usually when the event time is the earliest (EARLIEST EVENT TIME). Therefore, the NODE of an event is divided into spaces (3 rooms) so that the required information can be filled into these spaces.



Gambar 4.8 Event Coding and Numbering

(Source: Sumardjito, 2011:2)

If in a series of EET activities from the initial event has been determined while the duration of each activity in the series was also known, each EET of each event can be calculated.

(Sumber: Sumardjito, *Network* Planning 2011:2)

Gambar 4.9 Earliest Even Time Calculation

So if it is determined that the initial EET event is 0 (EET1 = 0), then :

EET 2 = 0 + 4 = 4

EET 3 = 4 + 10 = 14

EET 4 = 14 + 16 = 30

3. Research Methodology

3.1 Research Approach

This research was conducted from July to November 2018 with a focus on ships that will carry out Hardepo activities in the 2019 fiscal year. This research was carried out on a maintenance activity of the Indonesian Navy operational units at the KRI level which carried out the main tasks in upholding sovereignty and maintaining security territory in the sea of the Republic of Indonesia.

The activities carried out aim to study and analyze the problems being faced. Besides looking for priorities of ships that will carry out Hardepo activities with references from the literature and the results of existing research on determining the priority of ships that will carry out Hardepo using the MCDM fuzzy approach.

3.2 Types of Data, Subjects and Research Objects.

3.2.1 Research Data Sources.

In this research, it is necessary to determine the field to be examined. The way to determine the area under study is by observing or brainstorming and interviewing the experts in their fields. Data collection based on how the collection consists of:

a. Primary data

Data primer diperoleh dari hasil pengumpulan data kuisioner, wawancara, *brainstorming* dan tanya jawab dengan koresponden yang bertindak sebagai decision maker dan expert dibidangnya yaitu Dismatal, Dislaikmatal, Disharkap, Dopusbektim dan Staf Operasi Koarmada II.

b. Secondary Data

While secondary data obtained from the results of literature studies or reference books relating to criteria and alternatives as well as browsing from the internet as other data in improving research.

3.2.2 Research Subjects.

The subject of the research here is Headquarters and Koarmada II, where Dismatal will make plans for maintenance activities at the Depo or Hardepo level on elements that are under Koarmada II.

3.2.3 Research Object.

The subjects of this study were all ships that were not ready and it was time to carry out intermediate repairs in the Koarmada II region, among others, as follows:

NO	TYPE/CLASS	UNIT
1	Badik - 624	Fast Ship
2	Kerapu - 812	Patrol Boat
3	Badau - 841	Patrol Boat
4	Teluk Jakarta - 541	Amphibious Ship
5	Pulau Rimau - 724	Mine Ship
6	Arun - 903	Assist Ship

Tabel 3.3 Hardepo Ship Plans TA 2019
(Source: Disharkap Koarmada II, 2018)

4. Data Analysis and Discussion

4.1 Data Analysis

This chapter contains the process of data collection, processing and discussion used as material for data analysis and interpretation. Data collection and processing are divided into two, namely in determining the criteria and priorities of ship hardepo. From the collection and processing of each of these data, the desired results can be obtained from this study.

a. KRI Keris – 624

The first alternative selection is KRI Keris - 624 under the Koarmada II speedboat. This ship has the main function as a fast ship with a gas turbine engine so it requires expensive costs and extra maintenance than the type of diesel engine. Currently Koarmada II only has 3 similar vessels. The age of the ship which has now reached 38 years so that the ability of the ship is not like before, there is some damage to the navigation system and weapons systems described in Table 4.1 below

Tabel 4.1 Technical Condition Data KRI Keris-624

NO	Technical Data	Condition(%)	Information
1	Ship Building	60	Porous Deck
2	Enginering	70	None
3	Navigation System	60	Broken Radar
4	Gunnery System	60	Broken Weapon
Ship Conditioin			Not Ready

(Source : Disharkap Koarmada II, 2018)

b. KRI Kerapu – 812

The second alternative selection is KRI Kerapu - 812. As a patrol boat, the operational hours of KRI Kerapu - 812 are very high because the operational costs of this ship are relatively low. The ship's current condition is at the base because there is some damage to its weapons system

Tabel 4.2 Technical Condition Data KRI Kerapu-812

NO	Technical Data	Condition (%)	Information
1	Ship Building	60	Porous Deck
2	Enginering	70	None
3	Navigation System	70	None
4	Gunnery System	60	Broken Weapon
Ship Conditioin			**Not Ready**

(Source : Disharkap Koarmada II, 2018)

c. KRI Badau – 841

The third alternative selection is KRI Badau - 841 which is a hybrid from Brunei Darussalam on April 15, 2011. KRI Badau - 841 was made at the Vosper Pty, Singapore Singapore shipyard on March 15, 1978. This ship is very active in carrying out operations because operating costs are relatively low . The damage to KRI Badau - 841 is in Table 4.3 below.

Tabel 4.3 Technical Condition Data KRI Badau-841

NO	Technical Data	Condition (%)	Information
1	Ship Building	60	Porous Deck
2	Enginering	60	Time to overhoule
3	Navigation System	60	None
4	Gunnery System	80	None
Ship Conditioin			**Not Ready**

(Source : Disharkap Koarmada II, 2018)

d. KRI Teluk Jakarta – 541

The fourth alternative is KRI Jakarta Bay - 541, this ship was made at the Tacoma Marine Industries Ltd. South Korea shipyard in 1981 and inaugurated into the ranks of the Indonesian Navy on August 8, 1982 and resides in the Amphibious Ship Unit Koarmada II. The current technical condition of the ship is explained in Table 4.4 below.

Tabel 4.4 Technical Condition Data KRI Teluk Jakarta-541

NO	Technical Data	Condition (%)	Information
1	Ship Building	60	Porous Deck
2	Enginering	60	Time to overhoule
3	Navigation System	60	Broken Radar,Gyro
4	Gunnery System	50	Broken Cannon
Ship Conditioin			**Not Ready**

(Source : Disharkap Koarmada II, 2018)

e. KRI Pulau Rimau – 724

The fifth alternative is the KRI of Rimau Island - 724, this ship is a former minesweeper from East Germany which was built in 1971. Currently the Indonesian Navy only has 4 minesweepers because the production costs are very expensive. The condition of the ship is currently at the base because there are some damaged equipment which is described in table 4.5 below

Tabel 4.5 Technical Condition Data KRI Pulau Rimau-724

NO	Technical Data	Condition (%)	Information
1	Ship Building	60	Porous Deck
2	Enginering	80	None
3	Navigation System	60	Broken Radar
4	Gunnery System	60	Broken Weapon
Ship Conditioin			**Not Ready**

(Source : Disharkap Koarmada II, 2018)

f. KRI Arun – 903

The last alternative is KRI Arun - 903, KRI Arun with hull number 903 (KRI ARN - 903) made at Swan Hunters Ship Builders Ltd. New Castle Upon Tyne England in 1969. The current condition of the ship is declared "Ready Limited" which means the ship is still limited can be operational but cannot operate optimally due to some damage.

Tabel 4.6 Technical Condition Data KRI Arun-903

NO	Technical Data	Condition (%)	Information
1	Ship Building	60	Porous Deck
2	Enginering	70	None
3	Navigation System	70	None
4	Gunnery System	70	None
Ship Conditioin			**Ready Unlimited**

(Source : Disharkap Koarmada II, 2018)

4.2 Criteria Data for Each Alternative

In determining the criteria the researcher conducted a discussion and brainstorming with several expert staff in the Hardepo field so that the following criteria were obtained;

a. Maintenance Hours Criteria (MHC)

Maintenance Hours Criteria (MHC) is a data used to determine the ship repair schedule. From the field research, there are several ships that have time to carry out intermediate maintenance, and two of them whose engine has entered the overhoule time, namely KRI BADAU - 841 and KRI Jakarta Bay - 541 shown in Table 4.7 below:

Tabel 4.7 Maintenance Hour Data (JOP)

NO	KRI	Operation hours (hours)	Information
1	KERIS - 624	21200	Time to Harmen
2	KERAPU - 812	28676	Time to Harmen
3	BADAU - 841	15007	Time to Overhoule
4	TELUK JAKARTA - 541	112545	Time to Overhoule
5	PULAU RIMAU - 724	23445	Time to Harmen
6	ARUN - 903	57567	Time to Harmen

(Source : Disharkap Koarmada II, 2018)

b. Operational Hours Criteria (OHC)

Operational Hours Criteria (OHC) is a data used to find out how long or how many hours the ship has carried out shipping operations.

Tabel 4.8 Operational Hours Criteria Data (OHC)

NO	KRI	Operational Hours (Hours)	Information
1	KERIS - 624	21200	-
2	KERAPU - 812	28676	-
3	BADAU - 841	15007	-
4	TELUK JAKARTA - 541	112545	-
5	PULAU RIMAU - 724	23445	-
6	ARUN - 903	57567	-

(Source : Staf Operasi Koarmada II, 2018)

c. Spare Parts Availability Criteria

The availability of spare parts is one of the determinants in carrying out repairs. Because it has a direct impact on the budget that will be issued. From the research directly in the field obtained the following data;

Tabel 4.9 Spare Parts Availability

NO	KRI	On Board Spare	Dopusbektim
1	KERIS - 624	Available	None
2	KERAPU - 812	None	Available
3	BADAU - 841	Available	Available
4	TELUK JAKARTA - 541	None	Available
5	PULAU RIMAU - 724	None	Available
6	ARUN - 903	None	None

(Source : Dopusbektim, 2018)

d. Floating Feasibility Criteria

Feasible Floating Ship is one of the requirements in determining repairs. The service that has the authority to determine the suitability of a ship is the Navy Material Worthiness Service (Dislaikmatal).

Tabel 4.10 Floating Feasibility Data

NO	KRI	Sertificate	Information
1	KERIS - 624	Feasible	Valid until 2018
2	KERAPU - 812	Feasible	Valid
3	BADAU - 841	Feasible	Expired
4	TELUK JAKARTA - 541	Feasible	Valid
5	PULAU RIMAU - 724	Feasible	Valid
6	ARUN - 903	Feasible	Valid

(Source : Satlaikmattim, 2018)

e. Operation Eligibility Criteria

Operation Eligible Vessel Criteria are the main requirements that must be owned by every ship that will carry out Operations.

Tabel 4.11 Operation Eligibility Data

NO	KRI	Sertificate	Information
1	KERIS - 624	Feasible	Valid until 2018
2	KERAPU - 812	Feasible	Valid until 2018
3	BADAU - 841	Feasible	Valid until 2018
4	TELUK JAKARTA - 541	Feasible	Valid until 2018
5	PULAU RIMAU - 724	Feasible	Valid until 2018
6	ARUN - 903	Feasible	Valid until 2019

(Source : Satlaikmattim, 2018)

f. Criteria for Combatable Ships

The combat feasibility of a ship is one of the conditions needed to carry out operations. All ships are still in combat-worthy categories except for KRI Jakarta Bay where the eligibility certificate has expired. The combat viability data is explained in Table 4.12 below

Tabel 4.12 Combat Feasibility Data

NO	KRI	Sertificate	Information
1	KERIS - 624	Feasible	-
2	KERAPU - 812	Feasible	-
3	BADAU - 841	Feasible	-
4	TELUK JAKARTA - 541	Expired	Not yet implemented
5	PULAU RIMAU - 724	Feasible	-
6	ARUN - 903	Feasible	-

(Source : Kolatarmada II, 2018)

4.3 Data processing

In processing data using fuzzy MCDM algorithm, following the sequence of processes is as follows (Liang & Wang, 1999):

a. a. Able to weight the results of the criteria level assessment. Labeling the results of weighting there are two scales in the assessment of the linguistic scale and numerical scale. Linguistic scale is divided into 5 levels of assessment, namely "very low", "low", "medium", "high" and "very high", while the assessment for numerical scale is between 1-10. In table 4.13 shows the results of questionnaire and respondent data recapitulation for the importance of qualitative criteria.

Tabel 4.13 Ecpert Data Recapitulation fot Criterion Values

NO	Criteria	E1	E2	E3	E4	E5	E6
1	Maintenance Hours Criteria (MHC)	8	8	7	7	8	7
2	Operational Hours Criteria (OHC)	7	6	7	6	7	6
3	Spare Parts Availability	8	8	8	7	8	7
4	Floating Feasibility	6	7	6	6	7	7
5	Operation Eligibility	9	9	8	8	9	10
6	Combat Feasibility	9	9	10	9	9	9

(Source : Pengumpulan data expert)

b. Label the results of alternative rating ratings.

Labeling the results of alternative rating ratings can be seen in Table 4.14 with the same scale as the criterion rating namely linguistic scale and numeric scale.

Tabel 4.14 Ecpert Data Recapitulation fot Alternative Values

NO	Criteria	Alternatif KRI	E 1	E 2	E 3	E 4	E 5	E 6
1	Maintenance Hours Criteria (MHC)	KRS - 624	7	8	9	8	7	7
		KRP - 812	8	7	7	8	9	8
		BDU - 841	8	6	9	7	8	9
		TJA - 541	9	9	7	9	9	8
		PRU - 724	8	8	8	8	8	9
		ARN - 903	8	7	8	8	9	9
2	Operational Hours Criteria (OHC)	KRS - 624	6	8	8	8	9	7
		KRP - 812	6	7	6	8	8	8
		BDU - 841	8	7	9	7	8	9
		TJA - 541	7	6	8	9	8	9
		PRU - 724	7	9	7	8	9	8
		ARN - 903	8	6	9	7	8	8
3	Spare Parts Availability	KRS - 624	7	9	6	6	7	7
		KRP - 812	6	6	7	7	7	6
		BDU - 841	9	9	9	9	9	9
		TJA - 541	8	8	8	8	6	7
		PRU - 724	9	6	7	8	8	7
		ARN - 903	8	8	8	8	7	6
4	Floating Feasibility	KRS - 624	7	9	8	7	7	8
		KRP - 812	7	8	9	8	8	9
		BDU - 841	8	8	7	7	9	8
		TJA - 541	9	7	7	6	7	7
		PRU - 724	8	9	8	8	7	8
		ARN - 903	8	8	8	8	8	9
5	Operation Eligibility	KRS - 624	7	8	7	8	8	8
		KRP - 812	9	7	8	6	9	8
		BDU - 841	9	8	8	9	9	8
		TJA - 541	8	7	8	7	7	9
		PRU - 724	8	8	8	9	9	7
		ARN - 903	7	8	7	8	7	7
6	Combat Feasibility	KRS - 624	8	9	8	8	8	8
		KRP - 812	9	8	9	9	8	8
		BDU - 841	8	7	8	7	9	9
		TJA - 541	9	8	8	6	6	8
		PRU - 724	7	8	9	8	8	8
		ARN - 903	6	7	9	8	8	8

(Source : Pengumpulan data expert)

c. Determine the middle value of a fuzzy number.

Fuzzy middle numbers are numbers obtained from the sum of the values that appear at each level of the linguistic scale divided by the number of scales by formula (3.1). The calculation results are then used to make TFN.

Tabel 4.15 TFN Expert for Criteria Assessment

NO	LINGUISTIC LEVEL	E1			E2			E3			E4			E 5			E6		
		ct	at	bt	ct	at	bt	ct	at	bt	ct	at	bt	ct	at	bt	ct	at	bt
1	Very Low																		
2	Low																		
3	Middle	1.0	6.0	7.6	1.0	6.0	7.6	1.0	6.0	7.7	1.0	5.0	7.5	1.0	5.5	7.0	1.0	6.0	7.5
4	High	6.0	7.6	9.0	6.0	7.6	9.0	6.0	7.7	9.0	5.0	7.5	9.0	5.5	7.0	9.0	6.0	7.5	9.5
5	Very High	7.6	9.0	10.0	7.6	9.0	10.0	7.7	9.0	10.0	7.5	9.0	10.0	7.0	9.0	10.0	7.5	9.5	10.0

(Source : Pengolahan Data *Fuzzy* MCDM)

Information : ct = Lower Limit for Criteria Assessment

at = Middle Limit for Criteria Assessment

bt = Upper Limit for Criteria Assessment

Table 4.16 is a TFN expert for the assessment of each alternative based on qualitative criteria. So that it can be shown in the membership function graph for each expert for alternative assessments. Where the value of each expert is shown in the lower bound value, middle value and upper bound value, according to equation (3.1).

Tabel 4.16 TFN Expert for every Alternative based on Criteria

E1			E2			E3			E4			E 5			E6		
qt	ot	pt	qt	ot	pt	qt	ot	pt	qt	ot	pt	qt	ot	pt	qt	ot	pt
1.00	6.00	7.63	1.00	6.00	7.63	1.00	6.00	7.64	1.00	6.00	7.74	1.00	6.00	7.61	1.00	6.00	7.67
6.00	7.63	9.00	6.00	7.63	9.00	6.00	7.64	9.00	6.00	7.74	9.00	6.00	7.61	9.00	6.00	7.67	9.00
7.63	9.00	10.0	7.63	9.00	10.0	7.64	9.00	10.0	7.74	9.00	10.0	7.61	9.00	10.0	7.67	9.00	10.0

(Source : Pengolahan Data *Fuzzy* MCDM)

d. Determine the aggregate weights of each qualitative criteria.

Respondents evaluate each selection criteria by using a linguistic scale to get the level of weight for the benefit of the criteria. Expert weight values for krteria on the linguistic scale shown in Tabel 4.13 are then evaluated against TFN experts for criteria evaluation (table 4.15) using equations (3.2), (3.3), and (3.4)

Tabel 4.17 Bobot Agregat Kriteria

NO	KRITERIA	Rata - rata Bobot		
		ct	at	bt
1	JOP (Jam Olah Pemeliharaan)	5.75	7.44	9.08
2	JOG (Jam Olah Gerak)	3.42	6.53	8.25
3	Ketersediaan Suku Cadang	5.75	7.92	9.42
4	KRI Layak Apung	3.42	6.50	8.36
5	KRI Layak Operasi	6.75	8.61	9.67
6	KRI Layak Tempur	7.44	9.08	10.00

(Sumber : Pengolahan Data *Fuzzy* MCDM)

e. Calculate the preference value of each alternative based on qualitative criteria.

To calculate the preference value of each alternative based on qualitative criteria, an aggregate weight calculation is performed for each alternative for each qualitative criterion. Aggregate fuzzy values can be found using equations (3.5), (3.6) and (3.7)

Tabel 4.18 Criteria Aggregate Weights

NO	Criteria	Alternative	Average		
			qit	oit	pit
1	Maintenance Hours Criteria (MHC)	KRS - 624	6.27	7.88	9.17
		KRP - 812	6.27	7.88	9.17
		BDU - 841	4.33	7.10	8.55
		TJA - 541	7.10	8.55	9.67
		PRU - 726	6.28	7.87	9.17
		ARN - 903	5.17	7.38	8.77
2	Operational Hours Criteria (OHC)	KRS - 624	4.33	7.11	8.54
		KRP - 812	3.50	6.84	8.31
		BDU - 841	6.27	7.88	9.17
		TJA - 541	4.33	7.11	7.21
		PRU - 726	5.71	7.83	9.11
		ARN - 903	5.44	7.61	8.94
3	Spare Parts Availability	KRS - 624	1.83	6.27	7.88
		KRP - 812	2.67	6.56	8.09
		BDU - 841	7.65	9.00	10.00
		TJA - 541	1.00	6.00	7.65
		PRU - 726	3.50	6.84	8.32
		ARN - 903	3.50	6.83	8.32
4	Floating Feasibility	KRS - 624	4.33	7.11	8.54
		KRP - 812	6.55	8.10	9.33
		BDU - 841	6.00	7.65	9.00
		TJA - 541	1.83	6.27	7.88
		PRU - 726	6.27	7.88	9.17
		ARN - 903	6.28	7.87	9.17
5	Operation Eligibility	KRS - 624	4.33	7.09	8.56
		KRP - 812	5.44	7.58	8.96
		BDU - 841	6.83	8.32	9.50
		TJA - 541	4.61	7.33	8.71
		PRU - 726	3.50	6.84	8.31
		ARN - 903	4.33	7.09	8.56
6	Combat Feasibility	KRS - 624	6.00	7.65	9.00
		KRP - 812	5.44	7.60	8.94
		BDU - 841	6.28	7.87	9.17
		TJA - 541	3.50	6.81	8.34
		PRU - 726	5.94	7.98	8.75
		ARN - 903	4.61	7.32	8.73

(Source : Pengolahan Data *Fuzzy* MCDM)

f. Calculate the value of the fuzzy index from the results of the assessment of each alternative for qualitative criteria (Gi).

Here Gi is not a triangular fuzzy number, but a fuzzy number. Gi = (Yi, Qi, Zi, Hi1, Ti1, Hi2, Ui1), with the formula (3.10), to (3.18) in the search Gi, calculated as follows :

Tabel 4.19 Evaluation Building Value

INDEX	ALTERNATIVE					
	KRS-624	KRP-812	BDU-841	TJA-541	PRU-726	ARN-903
Yi	25,01	27,17	33,95	20,81	27,51	25,57
Qi	55,24	57,05	61,41	53,89	57,74	56,23
Zi	78,69	80,34	80,37	75,47	80,20	79,74
Hi1	1.93	2.04	3.14	1.87	2.07	2.12
Ti1	6,218	5,946	3,767	6,799	6,065	5,964
Hi2	6,15	6,37	6,74	6,76	6,52	6,35
Ui1	2,1	2	1,8	1,7	1,9	2
Ti2	23,99	24,24	23,62	25,40	25,06	25,30
Ui2	-25,53	-25,28	-24,79	-23,31	-24,33	-25,52

(Source : Pengolahan Data)

g. Calculates the utility value of each alternative for qualitative criteria.

Before calculating the value of Utilities first the Defuzzification process with the method used is the centroid method. By using equations (3.24) and (3.25). in its calculations using the microsoft mathematic program.

Tabel 4.20 Defuzzification of Criteria and Alternative Weights

NO	KRITERIA	DEFUZZIFICATION WEIGHTS	DEFUZZIFICATION ALTERNATIVE					
			KRS - 624	KRP - 812	BDU - 841	TJA - 541	PRU - 726	ARN - 903
1	MHC	7.426	7.773	7.773	6.661	8.436	7.773	7.106
2	OHC	6.065	6.661	6.217	7.773	6.217	7.106	6.661
3	Spare Parts Availability	7.694	5.328	5.773	8.884	4.884	6.661	6.217
4	Floating Feasibility	6.093	6.661	7.995	7.550	5.328	6.217	7.773
5	Operation Eligibility	6.343	6.661	7.328	8.217	6.884	7.773	6.217
6	Combat Feasibility	6.943	7.550	7.328	7.773	6.217	6.217	7.550

(Source : Pengolahan Data)

The total performance value is obtained by multiplying the average criteria weight and alternative values for each de-differentiated criteria, p The total of the multiplication criteria for each alternative is then divided by the number of criteria, in this case there are 6 qualitative criteria, such as the results of multiplication criteria Qualitatively towards alternative 1 above with a total of 302.04 / 6 the result is 50.34. Calculation of criteria weights against other alternatives using the Microsoft Excel program. For the results of the division then becomes a performance value for each alternative shown in table 4.21 below:

Tabel 4.21 Alternative Performance Values

ALTERNATIVE	Gi
KRS - 624	50.34
KRP - 812	52.41
BDU - 841	58.04
TJA - 541	47.14
PRU - 726	51.63
ARN - 903	51.17

(Source : Pengolahan Data *Fuzzy* MCDM)

As for the results of the calculation of the value of other alternative utilities using Microsoft Excel. For the utility value of each alternative is shown in table 4.22 as follows:

Tabel 4.22 Utility Formation Indekx

ALTERNATIVE	UtGi
KRS - 624	1.482
KRP - 812	1.631
BDU - 841	1.640
TJA - 541	1.548
PRU - 726	1.682
ARN - 903	1.475

(Source : Pengolahan Data)

h. Calculate the ranking of each alternative based on qualitative criteria.

By using equations (3.26) :

$ST_i = \frac{U_T(G_i)}{\sum_{i=1}^{m} U_T(G_i)}$ which $\sum_{i=1}^{m} U_T(G_i) =$ 1,482+1,631+1,640+ 1,548+1,682+1,475 = 9,458

$ST_i = \frac{1,482}{9,458}$ = 0,1566 (for alternative 1)

For alternative STi calculations use the Microsoft Excel program. After all calculations are done the ranking for alternative KRI is as follows:

Tabel 4.23 Alternative Rank

ALTERNATIVE	Sti	RANK
KRS - 624	0.156693	5
KRP - 812	0.172443	3
BDU - 841	0.173433	2
TJA - 541	0.163661	4
PRU - 726	0.177860	1
ARN - 903	0.155910	6

(Source : Pengolahan Data)

4.4 Determining the Docking Time Duration

After knowing the priority, the next step is to calculate the repair time of the ship above the dock based on the work standards carried out by PT PAL so that it can know the duration of each KRI's docking by calculating each docking activity for each KRI. In this process the standard time required for each PT PAL activity is shown in table 4.24 below:

Tabel 4.24 PT PAL Work Standardization

Activity	Work Load/ Hours	Unit
Underwater Hull		
Scrap (Bottom Side)	40	m²
Washing with fresh water (Bottom Side)	35	m²
BGA Painting	35	m²
Sweepblasting	136	m²
Spotblasting	21	m²
Ultrasonic Test BGA	58	Node
Zink Anode Replacement	38	Each
Surface Hull		
Washing with fresh water	35	m²
Sweepblasting	136	m²
Spotblasting	21	m²
AGA Painting	35	m²
Dreraft Mark, Water line and Hull Number Painting	5	m²

(Source : Divisi Docking PT PAL 2018)

Table 4.24 above is the standardization of work data that is capable of being carried out by PT PAL Indonesia based on equipment capability and the number of standard workers carried out by PT PAL. After PT PAL's work standard is known then look for the docking area for each KRI shown in table 4.25 below:

Tabel 4.25 Technical Docking Data

Technical Data	KRI						Unit
	PRU	BDU	KRP	TJA	KRS	ARN	
Long	56,79	36,88	58,10	100	53,58	140,7	M
Wide	7,73	7,16	7,62	15,4	8	19	M
Underwater Large	109	91	117	1120	115	2150	M²
Surface Large	415	266	443	875	420	1100	M²
Ultrasonic test	180	150	200	300	200	400	Node
Amount of Zink Anode	50	40	40	110	50	235	Each

(Source : Disharkap Koarmada II, 2018)

So after the standard work data and docking technical data of each KRI is known then multiplied so that the duration of each activity is shown in the table below

Tabel 4.26 Time Duration for Each Work

Activity	Work Duration (Hours)					
	PRU 724	BDU 841	KRP 812	TJA 541	KRS 624	ARN 903
Underwater Hull						
Scrap (Bottom Side)	2.73	2.28	2.93	28.0	2.88	53.8
Sweepblasting	3.11	2.60	3.34	32.0	3.29	61.4
Spotblasting	5.19	4.33	5.57	53.3	5.48	102.4
Washing with fresh water	0.80	0.67	0.86	8.2	0.85	15.8
Ultrasonic Test BGA	3.10	2.59	3.45	5.2	3.45	6.9
Zink Anode Replacement	1.32	1.05	1.05	2.9	1.32	6.2
BGA Painting	15.57	13.00	16.71	160.0	16.43	307.1
Surface Hull						
Sweepblasting	11.86	7.60	12.66	25.0	12.00	31.43
Spotblasting	19.76	12.67	21.10	41.7	20.00	52.38
Washing with fresh water	3.05	1.96	3.26	6.4	3.09	8.09
AGA Painting	59.29	38.00	63.29	125.0	60.00	157.14
Dreraft Mark, Water line and Hull Number Painting	4	3	4	4	4	8

(Source : Pengolahan Data)

4.4.1 Determine the Network Diagram

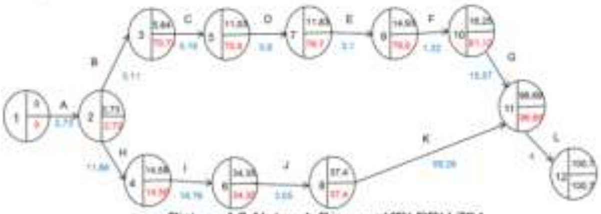
After knowing the duration of each type of work, the next step is to determine the order of work with the Critical Path Methods. This method shows the various types of activities in the reparation project as well as the dependencies and duration of each activity that will be used as a basis and and guidance in making ship docking network planning.

Tabel 4.27 Activity Notation and Duration

Activity	Notasi	Dep	Work Duration (Hours)					
			PRU	BDU	KRP	TJA	KRS	ARN
Below Water Line Work								
Scrap (Bottom Side)	A	-	2.73	2.28	2.93	28	2.88	53.8
Sweepblasting	B	A	3.11	2.6	3.34	32	3.29	61.4
Spotblasting	C	B	5.19	4.33	5.57	53.3	5.48	102.4
Washing with fresh water	D	C	0.8	0.67	0.86	8.2	0.85	15.8
Ultrasonic Test BGA	E	D	3.10	2.59	3.45	5.2	3.45	6.9
Zink Anode Replacement	F	E	1.32	1.06	1.06	2.9	1.32	6.2
BGA Painting	G	F	15.57	13	16.71	160	16.43	307.1
Above Water Line Work								
Sweepblasting	H	A	11.86	7.6	12.66	25	12	31.43
Spotblasting	I	H	19.76	12.67	21.1	41.7	20	52.38
Washing with fresh water	J	I	3.05	1.96	3.26	6.4	3.09	8.09
AGA Painting	K	J	59.29	38	63.29	125	60	157
Draft Mark, Water line and Hull Number Painting	L	G,K	4	4	4	4	4	8

(Source : Pengolahan Data)

From the data table 4.27 above then used to make the network diagram shown in Figure 4.2 below.



Picture 4.2 *Network Diagram* KRI PRU-724

(Source : Pengolahan Data)

From the network diagram, it is found that the total time activity for each KRI alternative is summarized in the table below

Tabel 4.28 KRI Docking Duration

Alternative KRI	EET	Docking Duration	
		DAY	HOURS
KRS - 624	100,7	4	4,7
BDU - 841	65,5	2	17
KRP - 812	107,2	4	11,2
TJA - 541	293,6	12	5,6
PRU - 726	102	4	6
ARN - 903	561,1	23	9,1

(Source : pengolahan data)

After the docking duration of each KRI, the next step is to determine the availability of docking facilities at PT PAL in 2019, which is shown in the table below

Tabel 4.29 Skenario Docking TW 1

Dock	KRS - 624	BDU - 841	KRP - 812	TJA - 541	PRU - 726	ARN - 903
Semarang	-	-	-	14 Januari	-	-
Irian	14 feb dan 25 maret	1 Januari	14 feb dan 25 maret	-	14 feb dan 25 maret	-

(Sumber : Pengolahan Data)

From table 4.29 above explained for KRI Keris, Grouper and Rimau Island have 2 alternative times and can carry out docking together at Irian dock, then for KRI Jakarta Bay only have 1 alternative, namely on January 14 at Semarang dock, KRI Badau has 1 alternative on January 1 in dock Irian while for KRI Arun cannot do docking on TW 1.

For the next scenario described in table 4.30 table 4.31 for TW 3 and table 4.32 for TW 4 below:

Tabel 4.30 TW 2 Docking Scenario

Dock	KRS - 624	BDU - 841	KRP - 812	TJA - 541	PRU - 726	ARN - 903
Semarang	-	3 Apr	-	3 Jun , 19 Apr	-	19 Apr
Irian	2 Jun	7 Mei	2 Jun	-	2 Jun	-

(Source : Pengolahan Data)

Tabel 4.31 TW 3 Docking Scenario

Dock	KRS - 624	BDU - 841	KRP - 812	TJA - 541	PRU - 726	ARN - 903
Semarang	31 Agt	8 Jul	31 Agt	-	31 Agt	-
Irian				26 Jul		26 Jul

(Source : Pengolahan Data)

Tabel 4.32 TW 4 Docking Scenario

Dock	KRS - 624	BDU - 841	KRP - 812	TJA - 541	PRU - 726	ARN - 903
Semarang	16 Okt	16 Okt	16 Okt	-	16 Okt	-
Irian	-		-	8 Okt	-	8 Okt

(Source : Pengolahan Data)

5. Conclusions and Suggestions

5.1 Conclusions

After carrying out the entire process of carrying out the final project, conclusions can be formulated based on the results of research methods and data processing and analysis, conclusions can be drawn as follows:

a. Criteria for ships that will carry out Hardepo include:

1) Maintenance Hours Criteria
2) Criteria for Operational Hours
3) Spare Parts Availability
4) Floating Feasibility
5) Operation Feasibility
6) Combat Feasibility

From the results of the research carried out the criteria that have the highest weight is the combat eligibility criteria with a value of 8.843 second order is the operation eligibility criteria with a value of 8.334 then in the third order is the availability of spare parts with a value of 7.694 then in the fourth is the JOP criteria with a value of 7.426 then The fifth is the floating eligibility criteria with a value of 6.093 and the last is the JOP criteria with a value of 6.065.

b. Based on the results of literature studies and consultations with experts in selecting Hardepo priorities for the Koarmada II region based on qualitative criteria for consideration, the right KRI priority sequence was obtained in implementing Hardepo namely KRI Rimau Island with a value of 0.1778 KRI Badau with a value of 0, 1734 KRI Kerapu with a value of 0.1724 KRI Jakarta Bay with a value of 0.1636 KRI Keris with a value of 0.1566 and KRI Arun with a value of 0.1559.

c. From the calculation of Docking Scheduling using Critical Path Methods (CPM), several time alternatives are obtained every quarter (TW). In TW I 2019 KRI Arun - 903 there was no space or place to carry out docking at PT PAL, but in TW 2, 3 and 4 all ships could carry out docking.

5.2 Suggestions

Suggestions that researchers against this study and for subsequent researchers are:

a. In the stage of determining criteria for the selection of Hardepo priorities, the researcher conducted a brainstorming with the experts so that there were no valid criteria determined by the Navy. For further research, it is suggested that the determination of criteria from the Navy so that it can be used as a procedure and can be applied in determining Hardepo priorities within the Navy.

b. In the hardepo priority setting the researcher does not calculate the costs in these activities, this makes it a challenge to further research in order to get maximum results from the determination of Hardepo priorities.

c. In calculating docking scheduling researchers only calculate the estimated longest docking time, but this can be maximized in subsequent studies so that the process of docking activities is faster and more efficient by adding workers to the docking provider.

d. The results of the study are solely as a suggestion and input for the organization, especially in determining the priorities of the KRI Hardepo and docking scheduling in the environment of Koarmada II.

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Note: Because of Confidential, all of data is Simulation only (not real), and purpose educational only for Improving Model.

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