DETERMINATION TIME INTERVAL REPLACEMENT OF CRITICAL COMPONENTS IN SPERRY MARINE BRIDGEMASTER E RADAR SATUAN KAPAL CEPAT KOARMADA II

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ABSTRACT

One aspect of KRI operation readiness is navigation equipment where the navigation radar as a system for detection and location of objects has vital function so that high radar readiness is needed to support operations. To fix or prevent system damage, scheduled maintenance management is needed. The critical components of the Sperry Marine Bridgemaster E Radar were determined using the FMECA and reliability models in this analysis. The Risk Priority Number (RPN) was calculated using the FMECA model and was used as a reference value when evaluating critical components. The Risk Matrix is used to analyze the RPN value of each component. Of the 20 (twenty) components found, 7 (seven) are considered critical. It is a DC motor drive, Interface Unit, Magnetron, Modulator, Power Supply Scanner, Electronic Processor Belt and Drive Belt. With a value of 51840, the DC Motor Drive component has the highest RPN value, while the Dive Belt component has the lowest RPN value of 43776. Modulator has the shortest replacement period of 128 days, while the Processor Electronic Unit has the longest replacement time of 271 days.

Keyword : FMECA, Time Interval of Replacement, *Risk Priority Number (RPN)*, *Reliability.*

1. INTRODUCTOIN

KRI as part of the Integrated Fleet Weapon System is the primary security force for Indonesia's maritime territory. The large area of water that must be protected presents a challenge for KRI in terms of being as present at sea as possible to protect the marine environment. Therefore, the operational readiness of KRI is needed in carrying out these tasks.

Satkatkoarmada II is Commander for Development which has the main task to strengthen the combat capabilities, namely anti-surface ship warfare and anti-air warfare. The navigation radar used by the KRI Satkatkoarmada II is shown in Table 1.1. A good navigation system is one of the components of KRI readiness and radar is one of the navigation systems. Radar is a vital role and has a long operating time. It has determined the object's location so that the KRI can navigate safely. A proper maintenance system is needed to maintain conditions so that the Radar is in high readiness. The Sperry Marine Bridge Master E Radar has been used by KRI in Satkatkoarmada II, mounted on KRI KRS-624 and KRI AJK-653, which is about 13 years old and has over 16,000 operational hours, requiring more regular inspection of technical conditions.

Herry (2015) suggests the Fuzzy and TOPSIS methods for FMEA on the Sperry Marine Navigation Radar system in evaluating critical components and corrective maintenance but does not account for the period for removing critical components. In this research plan proposed model of Failure Mode Effects and Criticality Analysis (FMECA) in determining the time interval replacement of critical components Sperry Marine Bridgemaster E Radar. At this time, if there is damage to the equipment/components, especially the navigation radar, it must wait for repairs, which takes a long time, while the ship has performed operational duties. This situation would make it difficult for KRI to perform operational duties. The purpose of this paper is to establish the mode of component damage so that can take measures to avoid damage.. Anticipate the need for replacement parts for equipment and components that are often damaged can be prepared. Since replacement parts are available, broken components can be repaired quickly, ensuring that KRI's readiness to complete the assignment.

Table 1.1 Use of Navigation Radar in Satkatkoarmada II. (Satkatkoarmada II, 2021)

No	Nama KRI	Radar Navigasi			
		Radar I		Radar II	
		Merk/Type	Usia (Th)	Merk/Type	Usia (Th)
1	KRI Mandau-621	Sperry Marine V Master	11	JRC JMA 5322	7
2	KRI Badik-623	JRC JMA 9225	6	JRC JMA 5320	17
3	KRI Keris-624	Sperry Marine B Master E	13	Sperry Marine V Master	5
4	KRI Sampari-628	Sperry Marine V Master	7	Sperry Marine V Master	7
5	KRI Tombak-629	Sperry Marine V Master	7	Sperry Marine V Master	7
6	KRI Hiu-634	Sperry Marine V Master	11	JRC JMA 5322	9
7	KRI Layang-635	JRC JMA 5312	15	JRC JMA 5320	12
8	KRI Terapang-648	Sperry Marine V Master	7	Furuno M-1935	7
9	KRI Singa-651	Raytheon Anschutz	2	Raytheon Anschutz	2
10	KRI Ajak-653	Sperry Marine B Master E	14	JRC JMR 9225	5

2. MATERIALS DAN METHODS

2.1 Radar*(Radio Detection and Ranging)*

According to Bole et all (2005), the word RADAR is an acronym derived from the words Radio Detection and Ranging. It's mean that radar has a function to detect and calculate range target by radio. According to Skolnik (1962), radar is an electromagnetic system to detects and locates objects that reflect electromagnetic waves emitted by the system. Objects can be in the form of aircraft, ships, spacecraft, motorized vehicles, humans, or the surrounding environment.

Radar works by emitting energy into the air and then detecting the reflected echo signal from an object or target. The energy returned to the radar not only shows the presence of the target but also provides additional information by comparing the received reflected signal to the emitted signal. Where optical and infrared sensor equipment has limitations, radar can operate at long and short distances. Radar's ability to accurately calculate the distance between objects and work under all weather conditions is a vital role of radar. The radar can operate in low light, foggy conditions, rain, and snow.

The basic principle of radar is illustrated in Figure 1.1. A transmitter generates an electromagnetic signal that is radiated into space by an antenna. A portion of the transmitted energy is intercepted by the target and reradiated in many directions. The radiation directed back towards the radar is collected by the radar antenna, which delivers it to a receiver. There it is processed to detect the presence of the target and determine its location. The target distance is calculated by calculating the time it takes for the radar signal to move from the target to the radar.

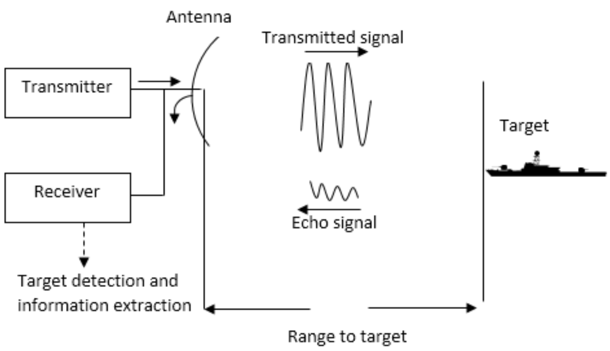

Fig 2.1 Basic Principle of Radar (Skolnik,1962)

2.2 Failure Modes Effects and Criticality Analysis (FMECA)

In certain cases, data to evaluate reliability quantitatively is insufficient, necessitating the use of another method to analyze reliability data qualitatively and based on experience. A system failure analysis is a qualitative analysis used to assess a system's reliability.

One of the analytical methods that can be used is the Failure Mode Effect and Criticality Analysis (FMECA). FMECA is a method used to identify the criticality or priority of a failure mode triggered by a component through an assessment analysis of Failure Mode and Effects Analysis. Failure Mode is used to rate each possible failure according to importance and impact so that allowing for preventive maintenance to minimize/eliminate failure.

According to Rausand (2004) the definition of FMECA is a methodology for defining and analyzing :

a. Types of possible failure modes of a subsystem.
b. The impact of system failures on the system.
c. How to prevent failure or reduce the impact of failure on the system.

Table 2.1 Severity Index

Rating	Effect	Severity Effect
10	Hazardous without warning	Very high severity ran- king when a potential failure mode effects safe system operation without warning
9	Hazardous with warning	Very high severity ran- king when a potential failure mode affects safe system operation with warning
8	Very High	System inoperable with destructive failure without compromising safety
7	High	System inoperable with equipment damage
6	Moderate	System inoperable with minor damage
5	Low	System inoperable without damage
4	Very Low	System operable with significant degradation of performance
3	Minor	System operable with some degradation of Performance
2	Very Minor	System operable with minimal interference
1	None	No effect

Source : Wang et all (2009)

Table 2.2 *Occurance Index*

Rating	Probability of occurance	Failure probability
10	*Very High* : failure is almost inevitable	> 1 in 2
9		1 in 3
8	*High* : repeated failures	1 in 8
7		1 in 20
6		1 in 80
5	*Moderate* : occasional failures	1 in 400
4		1 in 8000
3		1 in 15000
2	*Low* : relatively few failures	1 in 150000
1		< 1 in 150000

Source : Wang et all (2009)

Table 2.3 *Detection Index*

Rating	Detection	The possibility of detection by the controller
10	Absulute Uncertainly	Design control cannot detect potential cause/ mechanism and subse- quent failure mode.
9	Very remote	Very remote chance the design control will detect potential cause/ mecha- nism and subsequent failure mode
8	Remote	Remote chance the design control will detect potential cause/mechanism and subsequent failure mode.
7	Very Low	Very low chance the design control will detect potential cause/ mecha- nism and subsequent failure mode.
6	Low	Low chance the design control will detect potential cause/mechanism and subsequent failure mode.
5	Moderate	Moderate chance the design control will detect potential cause/mecha- nism and subsequent failure mode.
4	Moderately High	Moderately high chance the design control will detect potential cause/me- chanism and subsequent failure mode.
3	High	High chance the design control will detect potential cause/mechanism and subsequent failure mode.
2	Very High	Very high chance the design control will detect potential cause/mecha- nism and subsequent failure mode.
1	Almost Certain	Design control will detect potential cause/mecha- nism and subsequent failure mode.

Source : Wang et all (2009)

Severity (S) is a factor that shows how serious the impact of a damage is to the next process. Occurance (O) is a factor that shows how often failure occurs in a certain period. Detection (D) is a factor that indicates how well a functioning control system can detect failures in the system's operation.

2.3 Probability Distributions

2.3.1 Weibul Distribution

The first step in calculating an equipment's or component's reliability is to understand the probability model of equipment damage data. The probability distribution was varying to reflect the most appropriate distribution for the data on equipment failure. The Weibull distribution is often used to assess a component's reliability. This is a flexible distribution because it can be transformed into another distribution by changing the scale and shape parameters.

. According to Jardine and Tsang (2013), the distribution Weibull can be presented in the form of two or three parameters. The pdf function of three parameters Weibull distribution expressed by :

$$f(t) = \frac{\beta}{\eta}\left(\frac{t-\gamma}{\eta}\right)^{\beta-1} e^{-\left(\frac{t-\gamma}{\eta}\right)^{\beta}} \quad (1)$$

where :

β = shape parameter, $\beta > 0$

Ƞ = scale parameter, Ƞ > 0

γ = location parameter, γ < first damage time

Reliability function for Weibull distribution can be expressed by :

$$R(t) = e^{-\left(\frac{t-\gamma}{\eta}\right)^{\beta}} \quad (2)$$

Failure rate can be expressed by :

$$\lambda(t) = \frac{\beta}{\eta}\left(\frac{t-\gamma}{\eta}\right)^{\beta-1} \quad (3)$$

.

2.3.2 Eksponensial Distribution

In the theory of reliability, waiting time and other queuing problems exponential distribution is used. This distribution can be used to explain the time distribution phenomenon that occurs when a component failure. According to Jardine and Tsang (2013), the exponential distribution's density function is expressed as follows :

$$f(t) = \lambda e^{-\lambda t} \quad ; t > 0, \lambda > 0 \quad (4)$$

and the cumulative distribution function is :

$$F(t) = 1 - e^{-\lambda t} \quad (5)$$

Where :
t = time
λ = constan failure rate

Reliability function for exponential distribution can be expressed by :

$$R(t) = 1 - F(t) = e^{-\lambda t} \quad (6)$$

Failure rate :

$$\lambda(t) = \frac{f(T)}{\mathrm{R}(t)} = \lambda \quad (7)$$

$$MTTF = \int_0^{\infty} R(t)dt = \frac{1}{\lambda} \quad (8)$$

2.3.3 Normal Distribution

The normal distribution is useful for explaining the effect of increasing time as it can define the time between damage associated with uncertainty, according to Jardine and Tsang (2013). The following is the normal distribution pdf function. PDF normal distribution expressed by :

$$f(t) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left[\frac{-(t-\mu)^2}{2\sigma^2}\right] \quad (9)$$

for t :
-∞ ≤ t ≤ ∞

Where :

σ = standar deviation of variable random T

μ = variable random average T

Cumulatif distribution function expressed by :

$$F(t) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left[\frac{-(t-\mu)^2}{2\sigma^2}\right] dt \quad (10)$$

Reliability function :

$$R(t) = \int_t^{\infty} \frac{1}{\sigma\sqrt{2\pi}} \exp\left[\frac{-(t-\mu)^2}{2\sigma^2}\right] dt$$

(11)

Failure rate :

$$\lambda(t) = \frac{\exp\left[-(t-\mu)^2 / 2\sigma^2\right]}{\int_t^{\infty} \exp\left[-(t-\mu)^2 / 2\sigma^2\right] dt}$$

(12)

2.4 Methodology

The analysis was carried out in stages to achieve the desired results. The flow chart for this analysis is shown in Figure 2.2.

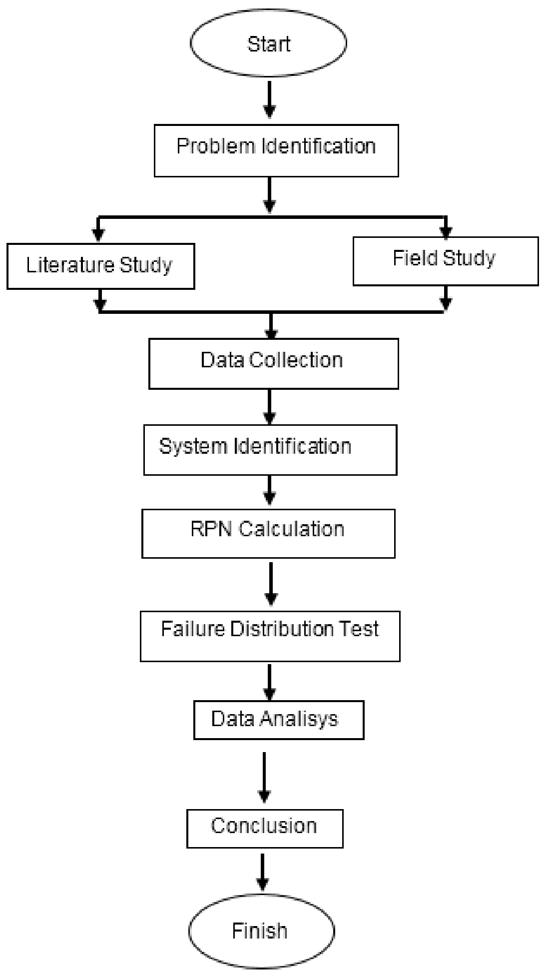

Fig 2.2 Research Flow Chart

3. RESULT AND DISCUSSION

3.1 Questionnaire Results of FMECA

The authors created a questionnaire with FMECA terminology and sent it to experts in the Sperrymarine Bridgemaster E Navigation Radar maintenance/repair system to collect data on the possibility of component failure mode. The Head of Fasharkan Lantamal V Electronics Workshop, Kasubdishar Sewaco Disharkap Koarmada II, Kasihar Sewaco Satkatkoarmada II, Head Department of Electronics KRI AJK-653, and Technician of PT Jala Purangga Sena became an expert in this questionnaire.

Data on rating severity, occurrence, and detection of each radar component was collected from the experts and then processed to calculation the RPN value. The RPN values are then sorted to provide a critical component ranking. The RPN value of the components is shown in Table 3.1.

Table 3.1 Risk Priority Number (RPN)

No	Components	RPN	Rangking
1	DC Motor Drive	51840	1
2	Interface Unit	50540	2
3	Magnetron	49096	3
4	Modulator	46620	4
5	Power Supply Scanner	44100	5
6	Processor Electronic Unit	44064	6
7	Scanner Control Unit	43956	7
8	Drive Belt	43776	8
9	GPS Antena	42840	9
10	Gyrosphere	41580	10
11	Memory Card	40460	11
12	Ups	39168	12
13	Tracker Ball	38080	13
14	Joystick	36960	14
15	Brilliance Control	35840	15
16	Keyboard	35805	16
17	PEU Fan	34782	17
18	CRT Monitor Fan	33660	18
19	Memory Card Battery	32116	19
20	Stavolt	31080	20

3.2 Determination of Critical Components

Each component is analyzed in terms the severity of consequency and severity of frequency and then processed into a risk matrix based on the criteria. The risk rating component's "high" has a higher average frequency of occurrence and severity of damage when compared to components with a rating of risk "acceptable" and "moderate". The analysis for each component of the risk matrix is shown in Table 3.2.

Table 3.2 Risk Rating of Component

No	Components	*Rating of Risk*
1	DC Motor Drive	High
2	Interface Unit	High
3	Magnetron	High
4	Modulator	High
5	Power Supply Scanner	High
6	Processor Electronic Unit	High
7	Scanner Control Unit	Medium
8	Drive Belt	High
9	GPS Antena	Accept

10	Gyrosphere	Accept
11	Memory Card	Accept
12	Ups	Accept
13	Tracker Ball	Accept
14	Joystick	Accept
15	Brilliance Control	Accept
16	Keyboard	Accept
17	PEU Fan	Accept
18	CRT Monitor Fan	Accept
19	Memory Card Battery	Accept
20	Stavolt	Accept

From the 20 components analyzed, it was found that critical components that have high risk and high RPN are shown in Table 3.3.

Table 3.3 Critical Components

No	Components	Category		Risk Matrix	RPN
1	DC Motor Drive	*Critical*	*Probable*	High	51840
2	Interface Unit	*Catastrophic*	*Occasional*	High	50540
3	Magnetron	*Critical*	*Probable*	High	49096
4	Modulator	*Critical*	*Probable*	High	46620
5	Power Supply Scanner	*Catastrophic*	*Occasional*	High	44100
6	Processor Electronic Unit	*Catastrophic*	*Occasional*	High	44064
7	Drive Belt	*Critical*	*Frequent*	High	43776

3.3 Analysis of Reliability Before Time Interval Replacement

Before the calculation replacement, the reliability value must be known in advance such that the time interval for the replacement can be determined to obtain the desired reliability value. Processing data use Reliasoft"s Weibull ++.

Table 3.4 Components Reliabilty Value before Replacement

No	Components	MTBF (Day)	*Reliability*
1	DC Motor Drive	267	0,5405
2	Interface Unit	271	0,5007
3	Magnetron	163	0,5029
4	Modulator	138	0,5325
5	Power Supply Scanner	169	0,5225
6	Processor Electronic Unit	264	0,4786
7	Drive Belt	212	0,4360

According to the calculations in table 3.4, the DC motor drive has the highest reliability value 0.5405, while Drive Belt has the lowest reliability value 0.4360. The replacement period must be determined based on the component reliability data above to increase component reliability as desired.

3.4 Analysis of Reliability After Time Interval Replacement

To achieve the optimal minimum reliability value, namely 0.95, the replacement time interval is determined by entering the variation of the replacement time interval. Modulator have the shortest replacement time, which is 128 days, while Processor Electronic Unit has the longest replacement time, which is 258 days, according to the measurement results shown in Table 3.5.

Table 3.5 Components Reliabilty Value after Replacement

No	Components	MTBF (Day)	Time Interval Replacement (Day)	*Reliability*
1	DC Motor Drive	267	224	0,95144
2	Interface Unit	271	232	0,95746
3	Magnetron	163	155	0,96480
4	Modulator	138	128	0,95037
5	Power Supply Scanner	169	162	0,97103
6	Processor Electronic Unit	264	258	0,95513
7	Drive Belt	212	205	0,95718

4. CONCLUSION

The following results can be drawn from the analysis and discussion that has done in the previous chapter :

a. Calculation of Risk Priority Number and Risk Matrix analysis using the FMECA method on the Radar Sperry Marine Bridge Master E, from the 20 components analyzed, 7 critical components are obtained DC motor drive, Interface Unit, Magnetron, Modulator, Power Supply Scanner, Processor Electronic Unit, and Drive Belt.

b. Based on the calculations, modulator has the shortest component replacement period of 128 days, while Processor Electronic Unit has the longest replacement time of 258 days.

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