Maintenance Strategy For Jakarta LRT Platform Screen Door Components Based on Failure Risk Using FMEA Method

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ABSTRACT

Platform Screen Door (PSD) is a security system on station platforms that is integrated with train doors and controlled by signaling equipment. This study analyzed the characteristics and impact of failures on PSDs to assess their reliability based on maintenance planning strategies for each piece of equipment. The FMEA method was used to identify component maintenance priorities based on RPN values. From the failure data, TTR and TTF could be calculated for input into the next calculation method. From this data, MTBF, MTTR, and data distribution were calculated using Minitab software to plan optimal maintenance intervals and spare parts management. The results revealed maintenance priorities on four components: the roller (RPN 32), the PSU module (RPN 40), the DDU module (RPN 48), and the wayside radio frequency (RPN 64). In the PSD subsystem, reliability was 28.09% with a maintenance interval of 21 days. The controller had a reliability of 31.82% with a maintenance interval of 23 days. The sensor had a reliability of 27.72% with a maintenance interval of 19 days. Additional equipment has 32.35% reliability with a maintenance interval of 25 days. Furthermore, Poisson proceed calculations show over a 95% probability, with 7 critical parts available for repairable RF Wayside components over the course of a year.

Keywords: FMEA, MTBF, MTTR, Reliability, Maintenance, PSD, Spare Parts

1. Introduction

1.1 Background

Platform Screen Door or PSD is a security system located on the station platform, in the form of a dividing door between the platform floor and the train floor (Rili et al., 2020). The PSD system plays an important role in train operations, therefore good maintenance is very necessary in its application. Maintenance is supported by maintenance strategies, both periodic and non-periodic maintenance, to ensure a high level of reliability. So it is necessary to predict maintenance activities to increase component reliability so that they function properly. In this research, FMEA is used as a precaution to determine actions that should be taken in the future to ensure the system continues to run well according to its function (Oktaviani, 2019). This method

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is used to determine critical components in the PSD system based on the RPN value indicator. This research was conducted to determine the characteristics of failures in the PSD system to determine the level of reliability and obtain maintenance planning strategies for each piece of equipment.

1.2 Research Objectives

There are 4 objectives in this research, namely:

1. To improve the characteristics of functional failures and determine maintenance priorities for Platform Screen Door equipment on the Jakarta LRT.
2. To determine the Reliability value of the Jakarta LRT Screen Door Platform equipment.
3. To find out the appropriate maintenance time interval before failure occurs on the Platform Screen Door equipment on the Jakarta LRT.
4. To find out spare parts planning for critical components of Platform Screen Door equipment on the Jakarta LRT.

2. Literature Review

2.1 Risk Definition

Risk is defined as the combination of how often and how likely something happens that has a harmful impact on a stated goal. Risks have a greater chance of occurring.

2.2 Definition of Treatment

Maintenance is an activity where equipment is maintained or maintains facilities and maintenance activities are carried out, adjustments, repairs, or parts of the necessary equipment are replaced so that the equipment is in the expected condition and ready to be used at any time.

2.3 Types of Treatment

The following are the general types of treatment, namely:

1. Preventive Maintenance is maintenance carried out at certain times or according to certain criteria at different stages of the production process. This maintenance aims to reduce the possibility of rapid damage to the machine and keep the machine working at all times.
2. Corrective Maintenance is maintenance work carried out if the results are not as expected including general or sudden damage to the machine, as well as quality, cost and timeliness. Corrective maintenance also includes maintenance performed after a system failure, the purpose of which is to restore the system to its operational state.

2.4 FMEA (Failure Mode Effect Analysis)

FMEA is a systematic approach that uses a tabular method that identifies failure modes, causes of failure and the effects of these failures to identify possible failure modes and their effects (Husen, 2021).

According to (Yumaida, 2011) the steps in making an FMEA are as follows:

1. Make a list of possible risks, causes and effects.
2. Determine the Severity level.
3. Determines the Occurrence level.
4. Determines the Detection level.

5. Calculating RPN.

2.5 Damage Rate Pattern

The failure rate of a component can be described by a bathtub curve, where the time variable is the failure rate of the component.

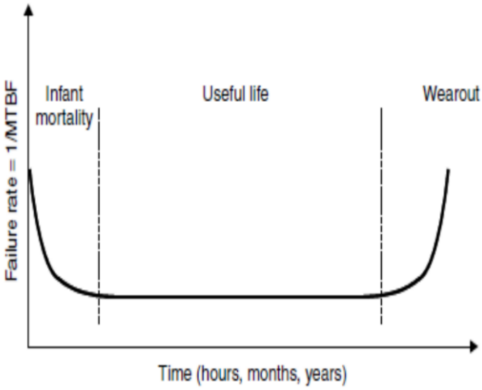

Figure 1. Curve Bath

2.6 Reliability Function

The reliability of a machine is greatly influenced by how the machine itself is maintained. Each component has the possibility of experiencing damage and a shift in its reliability value, because machine reliability decreases over time (Aritonang et al., 2023).

2.7 Reliability Distribution

1. Weibull Distribution
   According to (Aritonang et al., 2023) the reliability function of the Weibull distribution is,
   $$\boldsymbol{R(t) = exp^{-\left(\frac{t}{\theta}\right)^{\beta}}} \quad (1)$$
2. Normal Distribution
   According to (Aritonang et al., 2023) the normal distribution reliability function is,
   $$\boldsymbol{R(t) = 1 - \Phi\left(\frac{Int-\mu}{\sigma}\right)} \quad (2)$$
3. Lognormal Distribution
   According to (Aritonang et al., 2023) the reliability function of the lognormal distribution is,
   $$\boldsymbol{R(t) = \Phi\left(\frac{Int-\mu}{\sigma}\right)} \quad (3)$$
4. Eksponensial Distribution
   According to (Fabrycky, 2014) the reliability function is formulated as,
   $$\boldsymbol{R(t) = e^{-\lambda}} \quad (4)$$

2.8 MTBF and MTTR

Mean Time Between Failure (MTBF) is the average time between failures, or the average time a component, subsystem or system operates without experiencing failure.

Mean Time To Repair (MTTR) is the average time for checking or repairing when the component or unit is checked until the component or unit is used or turned on again.

The MTBF and MTTR of each distribution are as follows:

Weibull Distribution

According to (Fikri et al., 2021) the Weibull distribution for MTBF and MTTR is:

$$MTBF = \theta . \Gamma\left(1 + \frac{1}{\beta}\right) \quad (5)$$

$$MTTR = \theta . \Gamma\left(1 + \frac{1}{\beta}\right) \quad (6)$$

Lognormal Distribution

According to (Haryono, 2016) the lognormal distribution for MTBF and MTTR is:

$$MTBF = \exp\left(\mu + \frac{1}{2}\sigma^2\right) \quad (7)$$

$$MTTR = \exp\left(\mu + \frac{1}{2}\sigma^2\right) \quad (8)$$

Normal Distribution

According to (Darmawan et al., 2017) the normal distribution for MTBF and MTTR is:

$$MTBF = \mu \quad (9)$$

$$MTTR = t_{med} e^{\frac{s^2}{2}} \quad (10)$$

Eksponensial Distribution

According to (Fabrycky, 2014) the exponential distribution for MTBF and MTTR is::

$$MTBF = \frac{1}{\lambda} \quad (11)$$

$$MTTR = \frac{1}{\lambda} \quad (12)$$

2.9 Maintenance Time Intervals

Total downtime per unit time can be described as a function of inspection frequency (n) (Jardine, 1973) :

1. Average repair time

$$\frac{1}{\mu} = \frac{MTTR}{\text{monthly working hours}} \quad (13)$$

2. Average inspection time

$$\frac{1}{i} = \frac{\text{an average of 1 inspection}}{\text{monthly working hours}} \quad (14)$$

3. Average damage per month

$$K = \frac{\text{Frequency of damage}}{\text{Period of damage}} \quad (15)$$

4. Optimal number of checks

$$n = \sqrt{\frac{k.i}{\mu}} \quad (16)$$

5. Inspection time interval

$$I = \frac{\text{monthly working hour}}{n} \quad (17)$$

2.10 Spare Parts Planning

Poisson Process is a method for calculating the need for spare parts in one period. Calculating the need for spare parts components are classified into components that can be repaired and cannot be repaired, because the calculations use different formulas (Adelia, Annisa Safira, 2022).

1. The formula for calculating the need for Non-Repairable components using the Poisson Process method is as follows:

$$\lambda t = \frac{1}{MTBF} t = \frac{A \times N \times M \times T}{MTBF} \tag{18}$$

$$P \leq \sum_{x=0}^{n} \frac{(\lambda t)^x e^{-\lambda t}}{x!} = e^{-\lambda t}\left[1 + \lambda_t + .. + \frac{(\lambda t)^n}{n!}\right] \tag{19}$$

2. The formula for calculating the need for repairable components using the Poisson Process method is as follows:

$$\lambda 1t = \frac{A \times N \times M \times R \times T}{MTBF} \tag{20}$$

$$\lambda 2 = \frac{A \times N \times M \times MTTR}{MTBF} \tag{21}$$

$$P \leq \sum_{x=0}^{n} \frac{(\lambda t)^x e^{-\lambda t}}{x!} = e^{-\lambda t}\left[1 + \lambda_t + .. + \frac{(\lambda t)^{n-1}}{(n-1)!}\right] \tag{22}$$

2.11 Platform Screen Door

Platform Screen Door (PSD) is a series of doors at a train or subway station, at the edge of the platform, which functions as a safety measure so that passengers do not fall onto the track and also so that passengers are not hit when the train passes. PSD can be operated manually or automatically. On the Jakarta LRT, the half height type PSD is used and there are 12 PSDs on each side. How PSD works:

1. All doors close tightly on the platform, the SEI/SDI light will turn green when the train is safe to enter the station, while it lights red when the train is not safe to enter the station.
2. LRV detection sensor detects incoming train.
3. RFID reader receives incoming train information.
4. The stop position sensor detects the LRV stop position.
5. When the LRV stops at the correct position within the Platform, the LRV door open command is transmitted to the LCP via the Wayside RF unit.
6. After receiving the door open command, the LCP sends the door open command to the DCU located on the Platform.
7. The DCU receives the door open command and immediately opens the ASD so that passengers can get off or get on the LRV.
8. The PSD door open information is transmitted to the LRV and when sending the door close command all doors close tightly and the SDI light turns green, the LRV can leave the Platform.

3. Research Methods

3.1 Data Collection Methods

Primary data and secondary data are used to support research, namely:

1. Primary Data

   The primary data required is as follows:

   a. The primary data needed is data on the failure of the Jakarta LRT Screen Door Platform from January 2021 to March 2023.

   b. . Data from a questionnaire conducted on LRT Jakarta Screen Door Platform technicians
2. Secondary Data
   a. The secondary data required is in the form of Screen Door Platform equipment component data, journals and manual books.

3.2 Data Analysis Methods

There are several analytical techniques used by the author to conduct research.

1. FMEA (Failure Mode and Effect Analysis)
   The data analysis method that the author uses in this research functions to identify the highest risk of failure in the PSD system so that maintenance priorities for the system are known. Next, maintenance strategy planning is carried out on the PSD sub-system to prevent failure before failure occurs. Planning a PSD treatment strategy is carried out by calculating:
   a. MTBF.
   b. MTTR.
   c. Reliability.
   d. Interval perawatan yang sesuai.
2. Poisson Process
   This method is used by the author to calculate the need for spare parts for critical components in one period.

4. Research Results

4.1 Selection of Systems to be Researched

This research focuses on the Jakarta LRT screen door platform equipment. Data was obtained from damage reports from January 2021 to March 2023.

4.2 System Description

The system description of the screen door platform equipment functions to determine system performance so that the limits of the system to be studied can be determined.

4.3 FMEA (Failure Mode and Effect Analysis)

The first step in this analysis is to process the results of the questionnaire carried out by PSD technicians to determine the level of severity, occurrence and detection which is then packaged in an FMEA worksheet or commonly called an FMEA Worksheet, this worksheet is used to find the Risk Priority Number (RPN) based on Severity, occurrence and detection levels of each component in each sub-system of the PSD so that maintenance priorities are obtained for each sub-system of the PSD based on the RPN.

Table 1. FMEA Platform Screen Door

Failure Mode and Effect Analysis				
Equipment (1)	**Function (2)**	**Funtional Failure (3)**	**Failure Mode (4)**	**Failure Effect (5)**

Failure Mode and Effect Analysis

Equipment (1)	**Function (2)**	**Funtional Failure (3)**		**Failure Mode (4)**		**Failure Effect (5)**
ASD	Part of the PSD that can open/close, so that passengers can enter the train.	1A	The ASD cannot be opened or closed.	1A1	Broken roller.	The ASD door cannot open/close properly because the roller is damaged.
DCU	Panel for opening and closing PSD manually and automatically, located under the fixed screen.	2B	The door cannot open or close	2B1	Components on the DDU module are burned	The ASD door cannot move because a component in the DDU module is burned
RF Wayside	Communication device with On-board unit to send and receive PSD open/close commands.	3C	RF On board Blinking train cannot enter the platform	3C1	RF Wayside incorrectly detects the train on the eastbound / westbound route	RF On board blinking because RF Wayside incorrectly detected the train's arrival path.
PSU	Power supply to the ASD PSD device	4 D	The door cannot open or close	4D1	The PSU module is damaged	The power is off so the door cannot open

4.4 Selection of Critical Components

Table 2 RPN Value

Sub System	Type of Failure	S	O	D	RPN
Pintu	Broken roller	4	4	2	32
Controller	DDU Modul burned out	4	3	4	48
Sensors	RF *Unit Wayside* misdetected	4	4	4	64
AE	The PSU Module is damaged	4	5	2	40

From the results of the processing that has been carried out to find severity, occurrence and detection values, the RPN value is used as a benchmark for selecting critical components for priority maintenance that needs to be repaired.

4.5 Calculation of MTBF and Component Reliability Values

To determine the MTBF value, Time To Failure (TTF) data is needed, namely the time between failures. TTF data is obtained from the time interval between failures of a component in the PSD system. This data will later be used to determine the MTBF value so as to obtain the reliability value of the equipment.

1. Calculation of MTBF and Door Reliability

From the TTF data, a suitability test was carried out to determine the Anderson Darling value using Minitab software to determine the distribution that will be used to determine the reliability of a component.

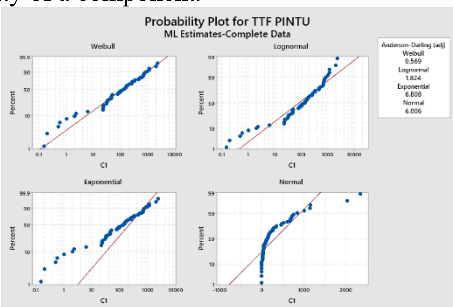

Figure 2 Door TTF Distribution Determination Test.

Based on Figure 2, the smallest Anderson-Darling value is 0.569 so the data has a Weibull distribution.

a. Calculating the MTBF value

To calculate the MTBF value, formula (2-5) is used with the Weibull distribution.

$\theta = 221{,}314 \; \beta = \; 0{,}607125$

$$MTBF = \; \theta . \Gamma \left(1 + \frac{1}{\beta} \right)$$

$$MTBF = 221{,}314\,.\,\Gamma\left(1 + \frac{}{0{,}607125}\right)$$

$$MTBF = 327{,}965 \text{ hours}$$

So the Door MTBF value is 327,965 hours

b. Component Reliability

The following calculation uses the reliability formula (2-1) to determine the reliability value.

$$t = MTBF,\ \beta = 0{,}607125, \theta = 221{,}314$$

$$R(t) = \exp -\left(\frac{t}{\theta}\right)^{\beta}$$

$$R(t) = e^{-\left(\frac{327{,}965}{221{,}314}\right)^{0{,}607125}}$$

So the current reliability value for the door is 28.09%.

2. Calculation of MTBF and Controller Reliability

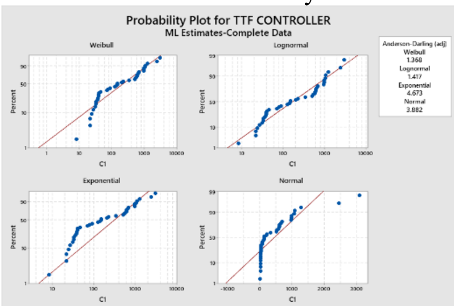

Figure 3 Test for Determining TTF Controller Distribution

Based on Figure 3, the smallest Anderson-Darling value is 1.368 so the data has a Weibull distribution.

a. Calculating the MTBF value

to calculate the MTBF value, formula (2-5) is used with the Weibull distribution

$$\theta = 373{,}524\ \ \beta = 0{,}709486$$

$$MTBF = \theta.\Gamma\left(1 + \frac{1}{\beta}\right)$$

$$MTBF = 373{,}542.\Gamma\left(1 + \frac{1}{0{,}709486}\right)$$

$$MTBF = 466{,}890 \text{ hours}$$

So the controller's MTBF value is 466,890 hours

b. Component Reliability

The following calculation uses the reliability formula (2-1) to determine the reliability value.

$$t = MTBF,\ \beta = 0{,}709486, \theta = 221{,}314$$

$$R(t) = \exp -\left(\frac{t}{\theta}\right)^{\beta}$$

$$R(t) = e^{-\left(\frac{466{,}890}{373{,}542}\right)^{0{,}709486}}$$

$$R(t) = 0{,}3182$$

So the current reliability value of the controller is 31.82%.

3. Calculation of MTBF and Sensor Reliability

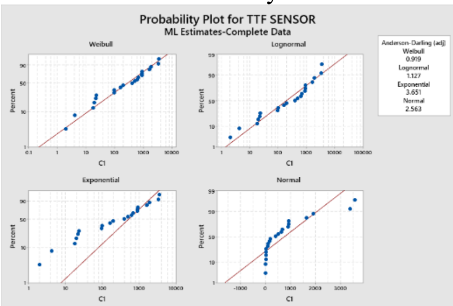

Figure 4 Sensor TTF Distribution Determination Test

Based on Figure 4, the smallest Anderson-Darling value is 0.919 so the data has a Weibull distribution.

a. Calculating the MTBF value

to calculate the MTBF value, formula (2-5) is used with the Weibull distribution

$$\theta = 529{,}625 \ \beta = \ 0{,}595401$$

$$MTBF = \ \theta.\Gamma\left(1+\frac{1}{\beta}\right)$$

$$MTBF = \ 529.625.\Gamma\left(1+\frac{1}{0{,}595401}\right)$$

$$MTBF = \ 804{,}997 \text{ hours}$$

So the MTBF Sensor value is 804.997 hours

b. Component Reliability

The following calculation uses the reliability formula (2-1) to determine the reliability value.

$$R(t) = \ exp^{-(\frac{t}{\theta})^{\beta}}$$

$$t = MTBF, \ \beta = 0{,}595401, \theta = \ 529{,}625$$

$$R(t) = \exp -(\frac{t}{\theta})^{\beta}$$

$$R(t) = e^{-\left(\frac{804{,}997}{529{,}625}\right)^{0{,}595401}}$$

$$R(t) = \ 0{,}2772$$

So the reliability value obtained on the current sensor is 27.72%

4. Calculation of MTBF and Reliability of Additional Equipment

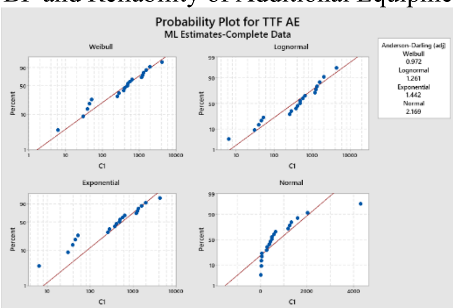

Figure 5 Test for Determining TTF AE Distribution

Based on Figure 5, the smallest Anderson-Darling value is 0.972 so the data has a Weibull distribution.

a. Calculating the MTBF value

to calculate the MTBF value, formula (2-5) is used with the Weibul distribution.

$\theta = 695{,}488\ \beta = \ 0{,}765638$

$$MTBF = \ \theta.\Gamma\left(1 + \frac{1}{\beta}\right)$$

$$MTBF = \ 695{,}488.\Gamma\left(1 + \frac{1}{0{,}765638}\right)$$

$MTBF = \ 814{,}416$ hours

So the MTBF value of additional equipment is 327,965 hours

b. Component Reliability

The following calculation uses the reliability formula (2-1) to determine the reliability value.

$$R(t) = \ exp^{-(\frac{t}{\theta})^{\beta}}$$

$t = MTBF, \beta = 0{,}607125, \theta = \ 221{,}314$

$$R(t) = \exp -(\frac{t}{\theta})^{\beta}$$

$$R(t) = e^{-\left(\frac{814{,}416}{695{,}488}\right)^{0{,}765638}}$$

$R(t) = \ 0{,}3235$

So the current reliability value for additional equipment is 32.35%.

4.6 Calculation of MTTR Values and Maintenance Intervals

To determine the MTTR value, Time To Repair (TTR) data is needed, namely the repair time. TTR data is obtained from the length of time a system or component is repaired when damage occurs. This data will later be used to determine the MTTR value so that the equipment maintenance time interval can be obtained.

1. Calculation of MTTR and Door Maintenance Intervals

From the TTF data, a suitability test is carried out to determine the smallest Anderson Darling value using Minitab software so that the distribution that will be used to determine the appropriate maintenance interval for a component is known.

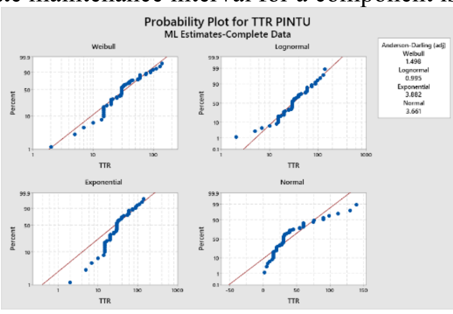

Figure 6 Door TTR Distribution Determination Test

Based on Figure 6, the smallest Anderson-Darling value is 0.995 so the data is lognormally distributed.

a. Calculating MTTR Values

To calculate MTTR values with a lognormal distribution.

$\mu = 3{,}41962 \quad \sigma = 0{,}761761$

$MTTR = \exp\left(\mu + \frac{1}{2}\sigma^2\right)$

$MTTR = \exp\left(3{,}41962 + \frac{1}{2}0{,}761761^{\,2}\right)$

$MTTR = 40{,}844$ minutes

Then the door MTTR value is 0.68073 hours

b. Component Maintenance Intervals

1) Average monthly working hours = 720 hours
2) Average one inspection = 45 minutes = 0,75 hours
3) Damage amount

   For 27 months = 59 times
4) Average repair time

$$\frac{1}{\mu} = \frac{MTTR}{montly\ working\ hours}$$

$$= \frac{0{,}68073}{720} = 0{,}00094546$$

$$\mu = \frac{1}{1/\mu} = \frac{1}{0{,}00094546} = 1057{,}686\ hours$$

5) Average inspection time

$$\frac{1}{i} = \frac{an\ average\ of\ 1\ inspection}{montly\ working\ hours}$$

$$= \frac{0{,}75}{720} = 0{,}001042$$

$$i = \frac{1}{1/i} = \frac{1}{0{,}001042} = 959{,}69\ hours$$

6) Average damage

$$k = \frac{frequency\ of\ damage}{period\ of\ damage}$$

$$= \frac{59}{27} = 2{,}19$$

7) Optimal inspection frequency

$$n = \sqrt{\frac{k\ x\ i}{\mu}} = \sqrt{\frac{2{,}19 \,.\, 959{,}69}{1057{,}686}}$$

$$= 1{,}409643$$

8) Inspection time interval

$$I = \frac{average\ working\ hours\ per\ month}{n}$$

$$= \frac{720}{1{,}409643} = 510{,}7676\ hours = 21 \text{ days}$$

2. Calculation of MTTR and Controller Maintenance Intervals

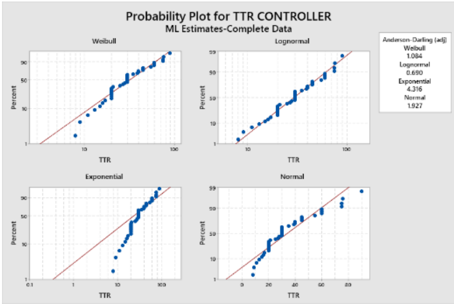

Figure 7 Test for Determining TTR Controller Distribution

Based on Figure 7, the smallest Anderson-Darling value is 0.690 so the data is lognormally distributed.

a. Calculating MTTR Value

To calculate the MTTR value with a lognormal distribution.

$\mu = 3{,}37554 \quad \sigma = 0{,}578288$

$MTTR = \exp\left(\mu + \frac{1}{2}\sigma^2\right)$

$MTTR = \exp\left(3{,}37554 + \frac{1}{2} 0{,}578288^{\,2}\right)$

$MTTR = 57{,}07545$ minutes

Then the MTTR Controller value is 0.95126 hours

b. Component Maintenance Intervals

1) Average monthly working hours = 720 hours
2) Average one inspection = 50 minutes = 0,83 hours
3) Damage amount
For 27 months = 41 times
4) Average repair time

$$\frac{1}{\mu} = \frac{MTTR}{montly\ working\ hours}$$

$$= \frac{0{,}95126}{720} = 0{,}00132119$$

$$\mu = \frac{1}{1/\mu} = \frac{1}{0{,}00132119} = 756{,}893\ hours$$

5) Average inspection time

$$\frac{1}{i} = \frac{an\ average\ of\ 1\ inspection}{montly\ working\ hours}$$

$$= \frac{0{,}83}{720} = 0{,}001153$$

$$i = \frac{1}{1/i} = \frac{1}{0{,}001153} = 867{,}303\ hours$$

6) Average damage

$$k = \frac{frequency\ of\ damage}{period\ of\ damage}$$

$$= \frac{41}{27} = 1{,}52$$

7) Optimal inspection frequency

$$n = \sqrt{\frac{k\ x\ i}{\mu}} = \sqrt{\frac{1{,}52\ .867{,}303}{756{,}893}}$$

$$= 1{,}319745$$

8) Inspection time interval

$$I = \frac{average\ working\ hours\ per\ month}{n}$$

$$= \frac{720}{1{,}319745} = 545{,}56\ hours = 23\text{ days}$$

3. Calculation of MTTR and Sensor Maintenance Intervals

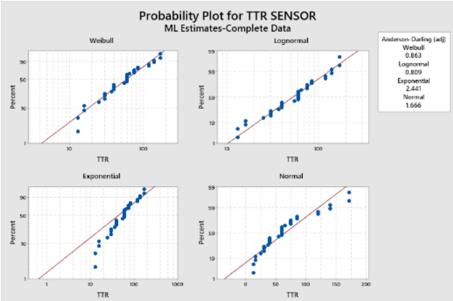

Figure 8 Uji Sensor TTR Distribution Determination Test

Based on Figure 8, the smallest Anderson-Darling value is 0.809 so the data is lognormally distributed.

a. Calculating MTTR Values

To calculate MTTR values with a lognormal distribution

$\mu = 3{,}96259\ \sigma = 0{,}701265$

$MTTR = \exp\left(\mu + \frac{1}{2}\sigma^2\right)$

$MTTR = \exp\left(3{,}96259 + \frac{1}{2}0{,}701265^{\ 2}\right)$

$MTTR = 140{,}6304$ minutes

So the MTTR Sensor value is 2.34384 hours

b. Component Maintenance Intervals

1) Average monthly working hours = 720 hours
2) Average one inspection = 45 minutes = 0,75 hours
3) Damage amount
   For 27 months = 22 times
4) Average repair time

$$\frac{1}{\mu} = \frac{MTTR}{montly\ working\ hours}$$

$$= \frac{2{,}34384}{720} = 0{,}00325$$

$$\mu = \frac{1}{1/\mu} = \frac{1}{0{,}00325} = 307{,}692\ hours$$

5) Average inspection time

$$\frac{1}{i} = \frac{an\ average\ of\ 1\ inspection}{montly\ working\ hours}$$

$$= \frac{0{,}75}{720} = 0{,}00104$$

$$i = \frac{1}{1/i} = \frac{1}{0{,}00104} = 961{,}53\ hours$$

6) Average damage

$$k = \frac{frequency\ of\ damage}{period\ of\ damage}$$

$$= \frac{22}{27} = 0{,}82$$

7) Optimal inspection frequency

$$n = \sqrt{\frac{k\ x\ i}{\mu}} = \sqrt{\frac{0{,}82\,.\,961{,}53}{307{,}692}}$$

$$= 1{,}60078$$

8) Inspection time interval

$$I = \frac{average\ working\ hours\ per\ month}{n}$$

$$= \frac{720}{1{,}60078} = 449{,}781\ hours = \ 19\text{ days}$$

4. Calculation of MTTR and Controller Maintenance Intervals

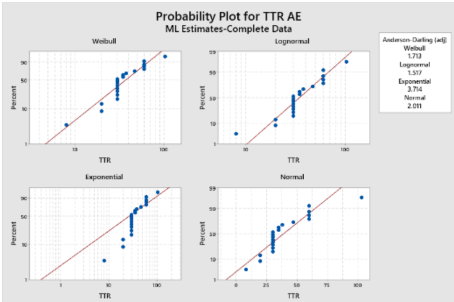

Figure 9 Test for Determining TTR AE Distribution

Based on Figure 9, the smallest Anderson-Darling value is 1.517 so the data is lognormally distributed.

a. Calculating MTTR Values

To calculate MTTR values with a lognormal distribution.

$\mu = 3{,}54455\ \sigma = 0{,}520250$

$MTTR = \ \exp\ (\mu + \frac{1}{2}\sigma^2)$

$MTTR = \ \exp\ (3{,}54455 + \frac{1}{2} 0{,}520250\ ^2)$

$MTTR = 59{,}49368$ minutes

So the MTTR value of additional equipment is 0.99156 hours

b. Component Maintenance Intervals

1) Average monthly working hours = 720 hours
2) Average one inspection = 30 minutes = 0,50 hours
3) Damage amount

   For 27 months = 20 times
4) Average repair time

$$\frac{1}{\mu} = \frac{MTTR}{montly\ working\ hours}$$
$$= \frac{0{,}99156}{720} = 0{,}00137$$
$$\mu = \frac{1}{1/\mu} = \frac{1}{0{,}00137} = 729{,}927\ hours$$

5) Average inspection time

$$\frac{1}{i} = \frac{an\ average\ of\ 1\ inspection}{montly\ working\ hours}$$
$$= \frac{0{,}50}{720} = 0{,}00069$$
$$i = \frac{1}{1/i} = \frac{1}{0{,}00069} = 1440{,}92\ hours$$

6) Average damage

$$k = \frac{frequency\ of\ damage}{period\ of\ damage}$$
$$= \frac{20}{27} = 0{,}74$$

7) Optimal inspection frequency

$$n = \sqrt{\frac{k\ x\ i}{\mu}} = \sqrt{\frac{0{,}74\ .\ 1440{,}92}{729{,}927}}$$
$$= 1{,}208638$$

8) Inspection time interval

$$I = \frac{average\ working\ hours\ per\ month}{n}$$
$$= \frac{720}{1{,}208638} = 595{,}7121\ hours$$ = 25 days

4.7 Spare Parts Planning

Calculation of spare parts requirements is carried out using the Poisson Process, where one period is equal to one year. Previously, components were classified into repairable or non-repairable components. In this research, spare parts planning will be carried out for components that are priority inspections that have the highest RPN values.

Table 3 Classification of Critical Components

Sub System	Type of failure	RPN	Maintenance Task	Type of component
Sensor	RF Wayside misdetected	64	Inspection	Repairable

A. Sensors

1. MTBF = 804,997
2. MTTR = 2,34384
3. A (Number of Components in Unit) = 1
4. P (Confidence Level) = 95%
5. N (Number of Units) = 1

6. T (Number of Periods) = 1 year = 12 months
7. M (Number of Machine Operations) = 720 hours/month
8. R (Scape Rate) = 30% = 0,30
9. Repairable λ1

$$\lambda 1t = \frac{A \times N \times M \times R \times T}{MTBF}$$

$$\lambda 1 = 0{,}966$$

10. Repairable λ2

$$\lambda 2 = \frac{A \times N \times M \times MTTR}{MTBF}$$

$$\lambda 2 = 2{,}093$$

11. Calculation of probability

Tabel 4 Probability of Repairable Components

	P(i; λ1=0,966)	P(i; λ2=2,093)
0	0,380	0,123
1	0,367	0,257
2	0,177	0,269
3	0,057	0,188
4	0,014	0,099
5	0,003	0,041
6	0,001	0,015

12. Calculation of spare part requirements for critical components is as follows:

Tabel 5 Spare Part Calculation Results

n-1	P	P%
0	0,0467	4,67%
1	0,1895	18,95%
2	0,4078	40,78%
3	0,6305	63,05%
4	0,8011	80,11%
5	0,9056	90,56%
6	0,9592	95,92%

From the calculation above it can be seen that to meet 95% availability for 1 year is 7 because in Table n-1 what must be met is 6, so n = 6 + 1 = 7 spare parts

5. Conclusion

The conclusions obtained from the results of the analysis that have been carried out are:

1. Priority maintenance of Screen Door Platform components based on the Risk Priority Number value using the FMEA method, 4 maintenance priority components in the PSD system are obtained, namely the Roller component on the ASD Door with an RPN value of 32, the PSU Module component on Additional Equipment with an RPN value of 40, components The DDU module on the

Controller has an RPN value of 48 and the Wayside Radio Frequency component on the Sensor has an RPN value of 64.

2. From the results of calculating the reliability value based on the selected distribution, we get:
   a. The door component is 28.9%.
   b. The controller component is 31.82%.
   c. The sensor component is 27.72%.
   d. Additional equipment components amounted to 32.35%.
3. Appropriate maintenance time intervals for components that fail are:
   a. The door component is 21 days.
   b. The controller component is 23 days.
   c. The sensor component is 19 days.
   d. Additional equipment components are 25 days.
4. Calculation of spare parts requirements for critical components, namely RF Wayside with a confidence level value above 95%, as many as 7 spare parts in one year.

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