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Dynamic Information System for Failure Analysis with It's Application on Ship Main Engine

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Abstract*— Ships are often used to move cargo, and their main engines are crucial. Accidents and financial losses might result from the main engine being in poor condition. Before completing maintenance, conducting a failure analysis is necessary. The existing method is static and involves using a list of failure modes from the engine's manufacturing phase. This study proposes a preliminary design of dynamic system prototype that seeks to improve ship engine monitoring of status. It includes features such as a list of failure modes and codes based on ISO 14224:2016, data collection unit worksheet, and dynamic charts for visualizing the results. Two testing iterations were performed on the prototype. First, literature data obtained from the internet was used to generate annual and monthly report charts, confirming the functionality of the prototype. Second, real data from engine failures on the tanker ship were used to ensure logical correlations among failure causative factors. The result from real data testing included Structural Deficiency (STD), External Leakage Fuel (ELF), and Breakdown (BRD) were shown. Based on these results through the prototype simulation, can be taken into consideration for the ship's crew and shipping company management to plan oil monitoring, heating the oil properly, and conduct routine maintenance check as a preventive action to reduce the impact of engine damage in the future due to Engine Breakdown and Structural Defiency.

Keywords— *Analysis, Dynamic, Failures, Information, Prototype Design, Ship Main Engine*

I. INTRODUCTION

Ship is the main asset and investment in term of producing revenue for the shipping companies. Many critical equipments on board the ship and has the risk to fail. Risk is defined as the probability and the consequences of the asset to get failures [1]. Poor condition of the ship's engine can cause accidents and significant losses, such as loss of life, environmental damage, and financial losses. If the main engine breaks down, the ship can't function properly, causing delays along the intended path, damage to machinery, and even the need for towing services, which can be expensive for the shipping company. Therefore, monitoring the condition of ship engines is crucial to ensure safety, prevent engine failures, and maintain performance.

In general, several maintenance options are available for shipping companies to choose from, depending on the most appropriate, such as preventive, corrective, and condition based. Corrective maintenance is a reactive approach to maintenance, performed in response to a system or equipment failure or breakdown. Preventive maintenance frequently depends on usage or time-based metrics such as km, fuel consumption, or running hours. Inspections, small adjustments, and other failure preventive procedures are used to carry it out. Recordings of observed conditions are often retained for trend analysis. The last option is condition-based maintenance, defined as the maintenance process that occurs according to equipment condition [2].

It is necessary to use some method and early warning of ship engine failure to reduce and also prevent losses. The FMEA (Failure Mode and Effects Analysis) method is one of the approach that usually can be used to give the crew some informations according to the engine failure. The application of the FMEA method to process of prediction and early warning of ship engine failure has several advantages, which can help minimize the risk of ship engine failure, increase the effectiveness of monitoring the condition of ship engines, and extend the life of ship engines.

Usually, the FMEA data are developed by an expert analysis in the design stage of an equipment. That means the Failure Modes (FM) data are still in the form of general data and static from the beginning of the manufacturing equipment. Failure modes must be thoroughly explained to know a maintenance strategy [3].

It is interesting to develop a failure analysis information system to help collect and process data by adopting existing list of failure modes and improve it from static data into that can be worked dynamic in the process of informing and early warning of ship engine failure. By improve into dynamic system, it will able to react earlier to prevent big damages and also identify new data based on real condition for some specific engine type.

This research goal is to develop a prototype of a system which can increase the effectiveness in term of monitoring ship engine conditions to give shipping company information about their engine failure data and make that information as references for the shipping company and crew in order to reduce risk of engine

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failure that can endanger the crew's safety and the operational success of the ship, increase pre-warning time of engine failure, and also reduce cost losses due to engine failure because ship engine failure can cause delays or even failure to complete the ship's voyage, even resulting in accidents and loss of life. Therefore, the use of appropriate methods to prevent engine failure is essential to the safe and successful operation of ships.

The meaning of " Dynamic Information System for Failure Analysis" in this research is that the prototype will be shown a dynamic result in dynamic chart form that can give information to the shipping company and crew from their data collection when some failures happened to their ship engine. Based on this chart, it will become a reference for the shipping company and crew to take appropriate preventive maintenance actions to reduce the impact of the same damage in the future.

II. LITERATURE REVIEW

As the Author planned, this research will utilizing a list of existing failure modes that still in the form of static into preliminary dynamic failure analysis prototype dyesign for ship main engines as the primary reference source, hence it is necessary to discuss the use of dynamic system, failure analysis, and the methods employed. The use of dynamic systems has been widely used in several aspects.

The use of dynamic systems using an adaptive machine learning was conducted. The research explained about the implementation of Dynamic Failure Analysis using machine learning in the ship energy systems. The research explained by Chuku et al. (2023), application of the Bayesian network, an adaptive machine learning formalization, for the evaluation of a ship propulsion engine failure taking into account nonlinear and nonsequential failure interactions. The model has the capacity to acquire new failure data and adjust the system's failure probability on an adaptive/dynamic basis [4].

The implementation of dynamic failure mode and effect analysis also was carried out by using Fuzzy Cognitive Map (FCM). In that study, discusses the risk of likely failures to improve the dependability of railway train systems. The research suggests a dynamic prioritizing method for FMEA that integrates the Fuzzy Cognitive Map (FCM) with prospect theory to fill in these gaps Wang et al. (2022). The method entails employing an enhanced weighted arithmetic averaging (WAA) operator to aggregate decision makers' assessments, building a risk matrix and linkages between risks using FCM, and establishing risk priorities using dynamic prospect theory [5].

The dynamic system also can be used to analyze the estimation of lifetime in order to save maintenance cost in rotary drilling system also was carried out. The main goal of the research by Kessai et al. (2022) is to calculate the useful life of the bottom toolstring on a rotary drilling machine. In this research, used many methods such as Finite Element Method (FEM), Rainflow Counting Method (RFM), Goodman Approach (GA), S-N diagram, and Miner's rule, has been developed [6].

The application of FMEA as a useful instrument for locating and averting possible problems throughout the life cycle of the engine. According to Faturachman et al. (2013), comprehensive FMEA documentation is a useful resource for executing design modifications, articularly when tackling extremely difficult and dangerous failure modes [5]. In another research, the use of FMEA also conducted as a prevention for ship engine crankcase explosion failure, the article uses the benefits of the FMEA to adopt innovative marine technology combined with the operational aspects. The study's primary goals are to increase operational safety principles on board ships and to increase mechanical system dependability. The paper's by Cicek & Celik (2013) findings may support ongoing efforts by companies that make maritime equipment, classification bodies, and ship owners [7].

A crankcase explosion is one of the examples of failure mode that can happen to ship main engine. Accidents at sea might have devastating effects on people's lives, goods, the environment, and finances. One of the most dangerous injuries is a crankcase explosion, which might endanger both the ship's structure and the crew. According to Ünver et al. (2019), identification of the underlying factors that lead to crankcase explosions and systematically computing the probability using field expert consultations is conducted. This research was using Fuzzy as fault tree analysis for system dependability and long-term shipping sustainability to find crankcase explosion in two-stroke marine diesel engines [8].

The failure of the diesel engine can be predicted. It is possible to conduct a failure prediction based on occurrence of selected wear particles in oil. The method differs from other research in that it uses actual diagnostic oil data as opposed to fictitious or hypothetical data. The report's research explained by Vališ et al. (2014) emphasizes the benefits and originality of the findings, which may be used to forecast failures, enhance preventative maintenance intervals, evaluate cost-benefit factors, and schedule operations and missions [9].

In the case of mechanical system reliability analysis, a method known as infinitesimal is used to investigate the coupling effects between the vibration of the machine worktable system and the wear of the linear guide. The analysis of wear and vibration failure processes is done using a nonlinear dynamic model that takes parameter uncertainty into account. The research is done by Wang et al (2021) through the use of active learning To analyze the dynamic reliability of the machine worktable system under various failure situations, a Kriging model and Monte Carlo simulation, as well as a time-variant and conditional reliability approach, are offered. The approach removes the need to repeatedly calculate the real limit state function values and greatly increases computing performance. on further explore the importance of random factors on the system's dependability, reliability-based sensitivity indices are offered [10].

III. METHODOLOGY

A. Description

The proposed methodological procedure is presented in figure 1. Regarding the formulation of the problem, this research consists of three main processes namely preliminary prototype design, testing with random data while still considering the logic of the loss value and the repair time using data literature obtained from the internet, and testing with using real data of engine failures from a tanker ship. The research object will be taken from MT. Ferimas Santosa owned by PT. Indoline Incomekita. The study data is based on real data of the ship from Main Engine maintenance manual, repair cost historical data, downtime effect cost, and interview with the management of the company that owned the ship.

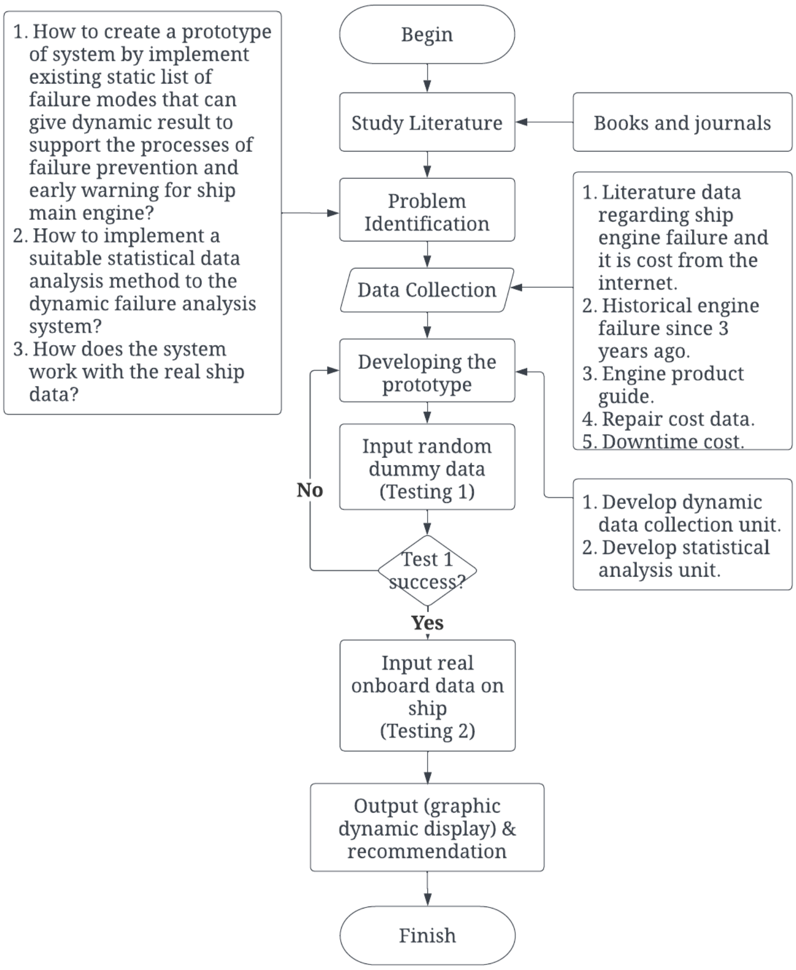

Figure 1. Research Diagram Methodology

B. Problem Identification

In this process, can be conclude as a starting point. Problem identification produce questions for this research. The main problem is to reduce cost losses and downtime due to engine failure. Thus, in this research, researcher conduct to create failure analysis system in order to help crew and shipping company by giving information about which engine failure modes has the most losses to the company business process. However, the development is required for the method's use in the process. Hence, question arose of how to create a dynamic failure analysis system by improving and adopting from existing failure modes data to the specific engine (MT. Ferimas). The system that can works "dynamic" it will give more precision from what actual things happen to the engine regarding the past engine failure data. Apart from that, the system is also designed to make it possible to provide suggestions for preventive actions. Therefore, the problems taken in this final project are expected to answer the expected goals.

C. Literature Study

A literature review is carried out by finding several books and journals that related to this research objectives. This is the first activity to obtain all information on the work of this final project. In this research, the Author conducted a literature study on five main points related to ship engine failure modes, ship main engine maintenance, data analysis, data visualization, and dynamic system failure analysis. Some literatures that the Author use in this study are as follows :

1. Uptime: Strategies for Excellence in Maintenance Management Third Edition. [11]
2. Reliability Centered Maintenance Book II. [12]
3. Troubleshooting and Repairing Diesel Engine. [13]
4. ISO 14224 : 2016 "Petroleum, petrochemical and natural gas industries — Collection and exchange of reliability and maintenance data for equipment" [14].

D. Building the Prototype System

Building the prototype is a process to create the early stage or initial version of this failure system. Depending on the complexity of the system or product being produced, prototypes can range from basic proof-of-concept models to more sophisticated and functioning representations. In this research, researchers have planned to create the prototype in a basic system. In the process of making this system, there are preliminary stage of features that will be put in the prototype such as data collection unit, statistical data analysis unit, and report displaying unit.

E. Dynamic Data Collection Unit

The data collection unit is a system that later will be used for inputting the data before it will analyzed in statistical analysis unit. The purpose of data collecting is to get data that fits the needs of this research for the next stage. The process of solving the problem begins after the end of data collection. Data in the form of failure mode and effect analysis (literature data), literature downtime cost, and repair cost data then will be inputted. This data collection unit will be made as dynamic system, means the data is possible to always updated regarding to the inputted data. Besides the literature data, the real data of historical failure mode, downtime cost, and also repair cost for the main engine failure were taken from the research object.

F. Statistical Analysis Unit

Statistical Analysis Unit planned to analyze data obtained from various sources to generate relevant and useful information. It will use various statistical techniques and analytical methods to explore the patterns, relationships and trends present in the data. Overall, the Statistical Analysis Unit has an important role in interpreting data into information that can be used for better decision-making. By using the right statistical methods and techniques, this unit will be used to understand the patterns in the data and identify the results of the data collection. The statistical analysis unit includes dynamic charts as the result output of this preliminary prototype.

G. Testing

In this research , 2 (two) times of system testing that will be conducted. First simulation will be conducted using dummy data from some literatures. The first simulation can be categorized as successful if the prototype can work properly which can be known by producing dynamic charts/graphs from the input results in the data collection unit. Then, second simulation will be conducted after the system is well-simulated in testing 1 using real data which is in this case the data will be collected from tanker ship owned by shipping company X. Researcher only use the “Most of Failure Causes and its Impact” that will be analyzed in the next stage with the goal to give insights to the shipping company regarding some prevention maintenance that possible to conduct to reduce frequency of the top failure mode, reduce the cost losses, and increase the prewarning time.

IV. RESULT AND DISCUSSION

A. Prototype Building Process

In this research, the prototype development was planned in the early stage system development. The Author planned to use Microsoft Excel as the basis software of early stage design. The prototype building process overview can be seen on the figure 2.

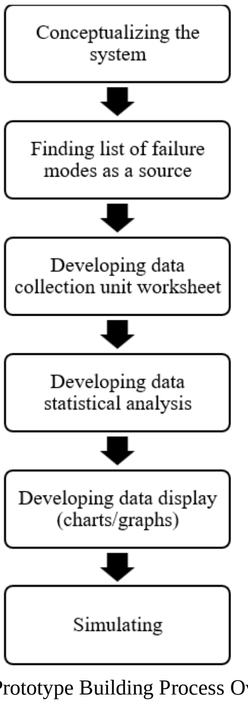

Figure 2. Prototype Building Process Overview

As shown in the figure 2, the process after conceptualizing is to find list of failure mode to make it as the source and limitation for the crew to inputting data. The list of failure mode taken from ISO 14224 : 2016 [14] and can be seen in the table 1.

TABLE 1.
LIST OF FAILURE MODES FOR COMBUSTION ENGINE BASED ON ISO 14224 :2016

Code	Description	Examples
AIR	Abnormal Instrument Reading	False alarm
		Fault instrument indication
BRD	Breakdown	Serious damages
ERO	Erratic Output	Oscilliating
		Hunting
		Instability
ELF	External Leakage Fuel	Leakage on fuel supply
ELU	External Leakage Utility Medium	Leakage on lubricating system
		Leakage on cooling system
FTS	Failure to Start	Doesn't start on demand
HIO	High Output	Overspeed/Over RPM
INL	Internal Leakage	Leakage internally on utility fluid process
LOO	Low Output	Output below acceptance
NOI	Noise	Abnormal noise
OHE	Overheating	Machinery parts
		Exhaust part
		Cooling water
PDE	Parameter Deviation Monitored Exceeding Limit	High alarm detected
		Low alarm detected
PLU	Plugged	Flow restrictions
SER	Service Problem	Discoloration
		Dirt
		Loose items
STD	Structural Defiency	Cracks
		Wear
		Fracture
		Corrosion
STP	Failure to Stop	Doesn't stop on demand
OTH	Other	Failure modes not covered above
UST	Spurious Stop	Unexpected shutdown
VIB	Vibration	Abnormal vibration

The data collection unit worksheet shown in table 2 This worksheet is the place to input data related to engine failure modes, cost losses due to downtime for maintenance (downtime cost), and also cost losses due to repair (repair cost). When a failure occurs, the user should categorize the type of failure based on the list of failure codes from the table 1. After that, the user can input the data into the data collection unit worksheet, the template of data collection unit worksheet that will be used which can be seen in the following table 2

TABLE 2.
WORKSHEET 1 – DYNAMIC DATA COLLECTION UNIT

Code	Failures Desc	Date	Economical				Prewarning time
			Downtime (hours)	Downtime cost	Repair cost	Total cost	
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-
(+) Add Failure Data Here							

Through calculation formula in Microsoft Excel, the failure data which was inputted in table 2 will be displayed and provide information regarding the failure level in sequence in the form of annual report, monthly report, and dynamic chart. The planned design template of annual report and monthly report can be seen on the table 3 and table 4.

TABLE 3.
ANNUAL FAILURE DATA REPORT

No.	Failure code	Frequency (peryear)	Total Cost (peryear)	Failure Level /Year
1.	-	-	-	-
2.	-	-	-	-
3.	-	-	-	-
4.	-	-	-	-

The failure level results in table 3 is depends on the failure occurrences and cost losses data. The more failure modes occurs or the most it causes the cost losses, then it will increase the failure level. The failure level which has the most critical failure will indicated with value of 1 (one).

TABLE 4.
MONTHLY FAILURE DATA REPORT

Month X	Avg Prewarning	Cost/case	Month (X+1)	Avg Prewarning	Cost/case
FM 1	-	-	FM 1	-	-
FM 2	-	-	FM 2	-	-
FM 3	-	-	FM 3	-	-
FM 4	-	-	FM 4	-	-
FM 5	-	-	FM 5	-	-
FM 6	-	-	FM 6	-	-
FM 7	-	-	FM 7	-	-

Based on the annual and monthly report, it will display the data on the dynamic chart that the preliminary design can be seen on the figure 3 and figure 4.

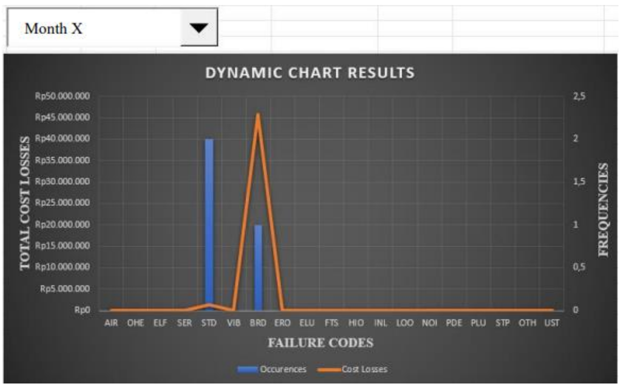

Figure 3. Scenario of Dynamic Chart Result Failure Data on Month X

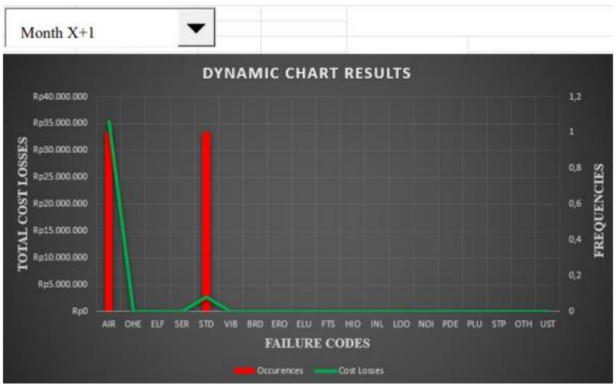

Figure 4. Scenario of Dynamic Chart Result Failure Data on Month X+1

In the figure 3, can be explain as the initial time of failure mode's data collection in the Month X. Based on the scenario that shown in Figure 3, the Failure Mode 2 (FM 2) is the highest failure level. By knowing this, the shipping company and the crew can carry out preventive maintenance plans in order to reduce losses due to this failure mode. In the scenario in the figure 4, it is shown that the losses due to Failure Mode 2 (FM 2) was reduced but another failure mode occur (FM 5) on 1 month after (Month X+1). The meaning of dynamic applied in the chart that can be explain as the chart always change it's value every new failure inputted and create dynamical analysis regarding to the chart result.

B. Prototype Simulation Process

After building the prototype, the simulation was conducted. As described in chapter 2, this research conducted 2 process of simulations.

1. Simulation Result using Literature Data

In this process, the Author created some scenarios then begin to input some random dummy data for the failure modes, downtime hours, downtime cost, and prewarning time into the data collection unit in worksheet 1 that shown on figure 5.

TABLE 1 - FAILURE CODES AND TYPE OF FAILURE DATAS								
Code	Mode Description	Date	Month	Economical Data				Prewarning time
				Downtime (hours)	Downtime cost	Repair cost	Total Cost (D+Repair)	
AIR	False alarm	01/01/2022	January	0	Rp0	Rp1.552.774	Rp1.552.774	20
ELF	Fuel Supply leakage	03/01/2022	January	2	Rp25.000.000	Rp3.074.800	Rp28.074.800	15
OHE	Exhaust valve damaged	21/01/2022	January	2	Rp15.000.000	Rp15.374.000	Rp30.374.000	12
SER	Discoloration oil	02/02/2022	February	2	Rp22.000.000	Rp15.374.000	Rp37.374.000	12
STD	Corrosion on cyl head	12/03/2022	March	5	Rp18.000.000	Rp38.435.000	Rp56.435.000	12
OHE	Engine overheat	14/03/2022	March	1	Rp17.500.000	Rp10.761.800	Rp28.261.800	10
OHE	Engine overheat	04/04/2022	April	5	Rp19.000.000	Rp7.687.000	Rp26.687.000	5
AIR	False alarm	08/04/2022	April	0	Rp0	Rp2.767.320	Rp2.767.320	2
VIB	Engine vibration abnormal	15/04/2022	April	3	Rp30.000.000	Rp4.227.850	Rp34.227.850	6
OHE	Crankpin bearing broken	20/04/2022	April	4	Rp15.000.000	Rp30.748.000	Rp45.748.000	1
AIR	False alarm	29/04/2022	April	0	Rp0	Rp2.767.320	Rp2.767.320	10
ELF	Supply leakage	15/05/2022	May	1	Rp20.000.000	Rp3.074.800	Rp23.074.800	12
OHE	Cylinder head overheat	01/06/2022	June	2	Rp16.000.000	Rp38.435.000	Rp54.435.000	14
AIR	False alarm	13/06/2022	June	1	Rp0	Rp2.767.320	Rp2.767.320	2
AIR	False alarm	29/06/2022	June	1	Rp0	Rp2.767.320	Rp2.767.320	1
AIR	False alarm	18/07/2022	July	1	Rp0	Rp2.767.320	Rp2.767.320	1
SER	Oil discolorization	30/07/2022	July	4	Rp20.000.000	Rp15.374.000	Rp35.374.000	4
ELF	Supply leakage	20/08/2022	August	1	Rp10.000.000	Rp3.074.800	Rp13.074.800	12
							Rp0	
AIR							Rp0	
BRD ERO							Rp0	
ELF							Rp0	
ELU							Rp0	
FTS HIO							Rp0	
INL							Rp0	

Figure 5. Simulation of Worksheet-Table 1 using Literature Data

The result of dynamic chart regarding to the random data inputted or simulation using literature data can be seen in the figure 6 as annual chart, figure 7 and figure 8 as examples of the monthly data report simulation result using literature data

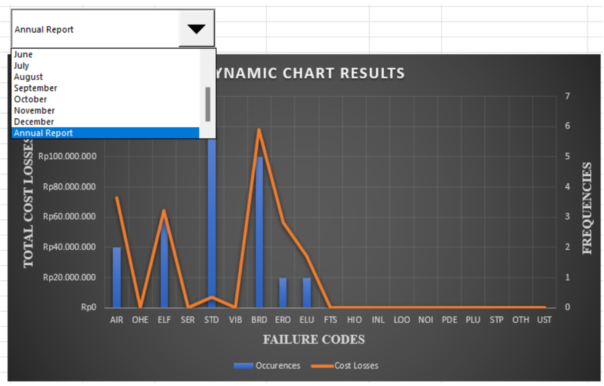

Figure 6. Dynamic Chart Result of Annual Engine Failure using Literature Data

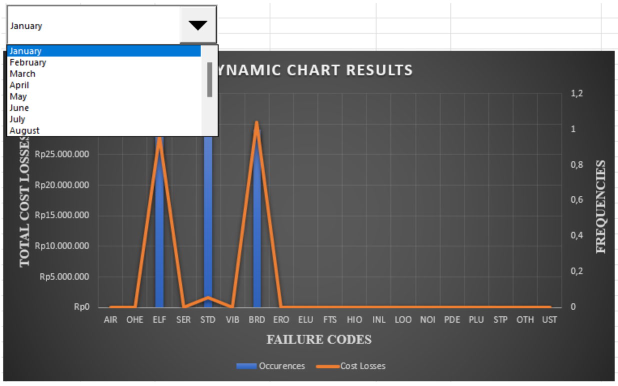

Figure 7. Dynamic Chart Result of Monthly (January) Literature Data Report

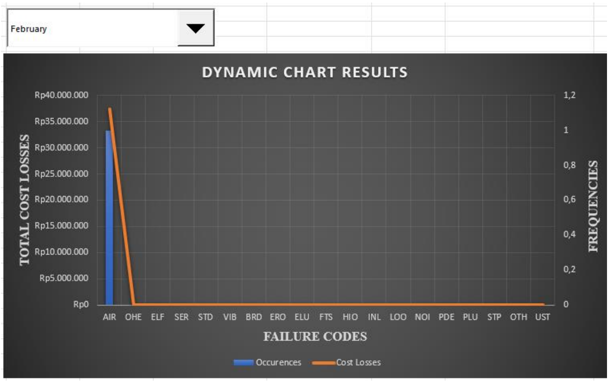

Figure 8. Dynamic Chart Result of Monthly (January) Literature Data Report

Regarding all of those simulations result using literature data from some scenarios, it can be concluded that the DFAS prototype has functioned as the goal for this research as because the dynamic chart was successfully to work dynamically. Hence, further testing will be carried out using real ship main engine failure data report with the case study on MT. Ferimas Anugerah.

2. Simulation Result using Real Data

The process of simulation using real data began with data collecting details regarding instances where engines have failed or malfunctioned is referred to as the collection of historical engine failure data owned by the company. Manual record-keeping was a factor, and records of maintenance contained information concerning engine failures. These records included details such as the type of failure, time of occurrence, main engine conditions, and the actions taken to address the issue. In this research, MT. Ferimas Santosa has it's own historical engine failure for the last 3 years that can be seen on the table 7. The ship and main engine data shown in the table 5 and 6.

TABLE 5.
SHIP DATA

Vessel name	:	MT. Ferimas Santosa
Flag	:	Indonesia
Type of vessel	:	Oil Tanker
DWT	:	780 Tons
LOA	:	70 m
CLASS	:	BKI

TABLE 6
SHIP ENGINE DATA

Manufacture	:	Hanshin
Model	:	6LB26G
Number of engine	:	1 (Single Engine)
Strokes	:	4 Strokes
Power	:	850 HP (625 KW)
RPM	:	400 RPM

TABLE 7.
SUMMARY OF ENGINE FAILURES ON MT. FERIMAS SANTOSA

Date	Failure modes	Cost		Downtime hours	Pre-warning time (hours)
		Downtime cost	Repair cost		
30/03/21	Broken main bearing on cylinder 2	0	Rp. 3,250,000	48 hours (2 days)	0
01/07/21	Leakage on fuel oil pipe	0	Rp. 50,000	3 hours	0
28/10/21	Trouble crank pin bearing cylinder 5	0	Rp. 17,500,000	48 hours (2 days)	0
17/12/21	Broken crankshaft cylinder 5	0	Rp. 215,000,000	336 hours (14 days)	0

Based on the table 7, the repair cost, downtime, and pre-warning time data were received from company's report data. The explanation for the downtime cost is that having Rp. 0 is because the ship doesn't need to pay the demurrage cost or the ship cargo transferred to another company's ship (reserve ship) due to the ship being unable to continue the voyage and should be docked. In that case, failure mode "Leakage on fuel oil pipe" has Rp. 0 due to it is downtime didn't affect the ship schedule a lot so there is no demurrage cost.

Meanwhile, the modes "Broken main bearing on cylinder 2", "Trouble crank pin bearing cylinder 5", and "Broken crankshaft cylinder 5" have Rp. 0 due to the ship cargo transferred to another company's ship (reserve ship) and should be docked. These reports, later will be inputted to the system as the following figure 9 and have the results in the form of dynamic graphs as the figure 10 until figure 14.

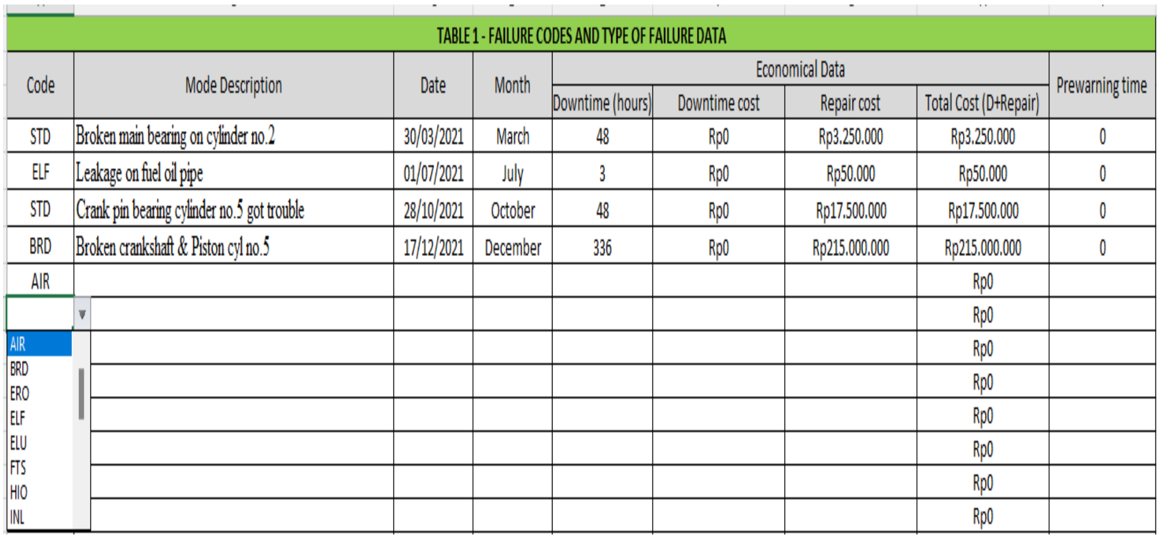

TABLE 1 - FAILURE CODES AND TYPE OF FAILURE DATA

Code	Mode Description	Date	Month	Economical Data				Prewarning time
				Downtime (hours)	Downtime cost	Repair cost	Total Cost (D+Repair)	
STD	Broken main bearing on cylinder no.2	30/03/2021	March	48	Rp0	Rp3.250.000	Rp3.250.000	0
ELF	Leakage on fuel oil pipe	01/07/2021	July	3	Rp0	Rp50.000	Rp50.000	0
STD	Crank pin bearing cylinder no.5 got trouble	28/10/2021	October	48	Rp0	Rp17.500.000	Rp17.500.000	0
BRD	Broken crankshaft & Piston cyl no.5	17/12/2021	December	336	Rp0	Rp215.000.000	Rp215.000.000	0
AIR							Rp0	
							Rp0	
							Rp0	
							Rp0	
							Rp0	
							Rp0	
							Rp0	
							Rp0	

Figure 9. Simulation of Worksheet 1 using Real Data

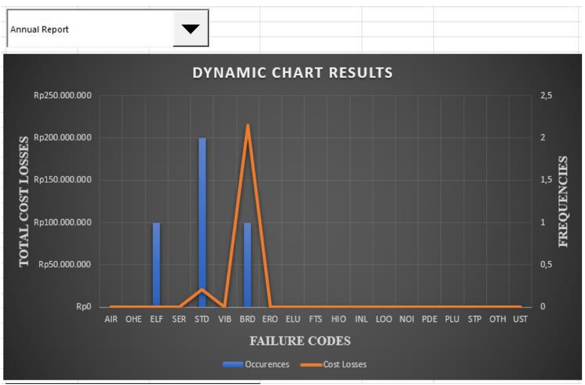

Figure 10. Annual Report Simulation Result using Real Data

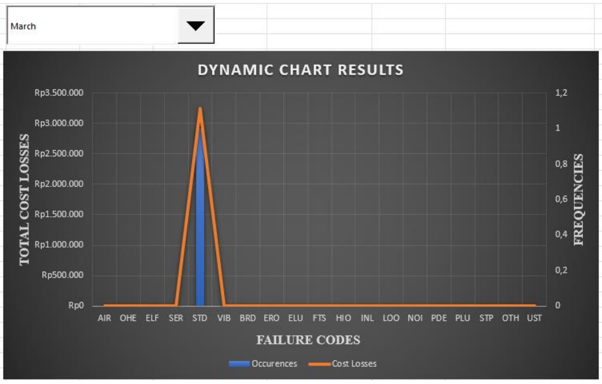

Figure 11. Dynamic Chart Simulation Result of Monthly (March) Real Data Report

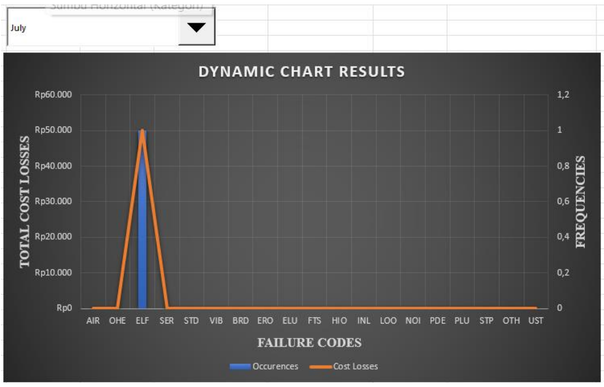

Figure 12. Dynamic Chart Simulation Result of Monthly (July) Real Data Report

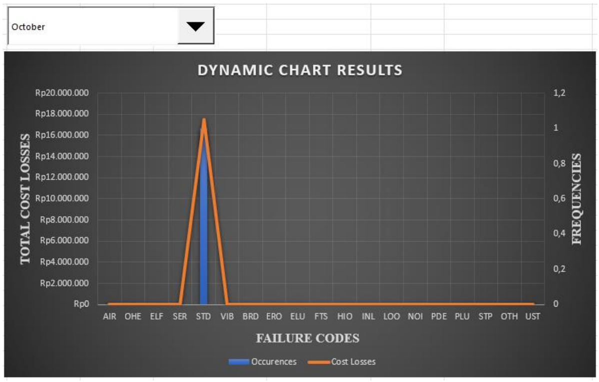

Figure 13. Dynamic Chart Simulation Result of Monthly (October) Real Data Report

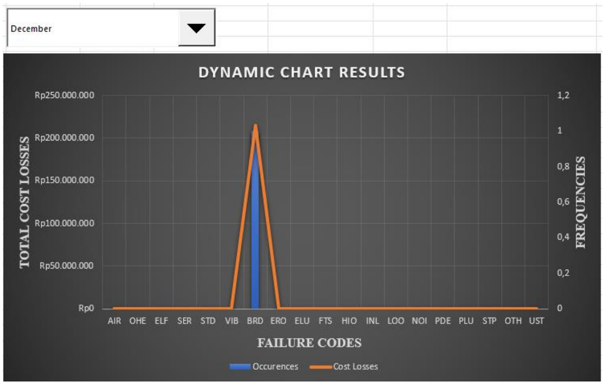

Figure 14. Dynamic Chart Simulation Result of Monthly (Desember) Real Data Report

C. Real Data Simulation Result Analysis

According to the simulation with the real data result, can be defined that the failures with the code "BRD" or "Breakdown" with the mode of description "broken crankshaft cylinder number 5" has the most expensive economical losses with the value Rp. 215,000,000. Meanwhile, the failures with the code "STD" or "Structural Defiency" and with the modes "Broken main bearing cylinder number 2" and "Crank pin bearing cylinder number 5 got trouble" have the most occurred with total 2 (two) occurrences per-year. Based on those 2 (two) categories (most expensive economical losses and most occurrences per-year), can be considered to conduct more effective preventive maintenance.

By using dynamic charts, it will make it easier for the ship's management and crew to check whether their preventive maintenance is successful or not. That is because if their preventive maintenance is successful, then the graph results on the future will show a reduction in cost losses and an increase in prewarning time. According to the simulation with the real data result also can be conclude that there are no pre-warning time at all. This indicates a sudden failure that cannot be detected or predicted in advance and this situation requires corrective maintenance to be carried out. Before conducting preventive maintenance, the symptoms of the failures need to be known.

Regarding to the damage analysis result report from the dockyard that responsible to the ship, concluded that some reasons made the engine can suffer total breakdown and need to be overhauled are imperfect lubrication and insufficient oil pressure during starting engine. The oil pressure did not reached the required pressure for the normal starting engine procedure (4 bar). Whereas, lubricating oil is a critical component in engine dependability, and its condition must be monitored.

D. *Suggestion Regarding The Occured Failures*

There are several common causes that can cause damage to the crank pin bearing and crankshaft on the ship's main engine that can suffer engine totally breakdown such as:

1. Wearing
2. Corrosion
3. Fatigue
4. Deformation

Some recommendations that might be implemented by the management and crew for preventive maintenance actions at MT. Ferimas Santosa referring to engine breakdown caused by imperfect lubrication and insufficient oil pressure for this cases are as follow.

1. Conduct oil monitoring

   Carry out a thorough inspection of the ship's engine lubrication system, including the oil pump, filters, oil passages and lubricating holes. Make sure there are no blockages, damage or leaks that could prevent proper oil flow. The oil monitoring also included to monitor the temperature of oil, oil pressure, and also schedule to change the oil.

2. Conduct oil pre-heating properly

   Before starting the ship's main engine, preheat it using a heater or additional oil circulation. This helps ensure proper lubrication when the engine is started. Besides, it will set-up the oil to it's required viscosity. For this type of engine, it is required pressure for the normal starting engine procedure (according to the engine product guide for this type of engine, the proper oil pressure is 4 bar).

3. Routine maintenance planning

   Create a routine maintenance schedule that includes inspection and maintenance of the lubrication system. Ensure that maintenance is conducted regularly related with the ship's engine manufacturer's recommendations

V. CONCLUSSION

Creating the system concept, selecting appropriate software, obtaining a list of failure modes, developing dynamic data collection and analysis worksheets, and creating a dynamic result display are all the steps to design prototype system of of dynamic information system for failure analysis. The findings from simulations using real data of engine failure were displayed using dynamic charts, which provide updated information with fresh data input. The result from real data testing included Structural Deficiency (STD), External Leakage Fuel (ELF), and Breakdown (BRD). The charts showed dynamically changing information and can assist the ship's crew and management in planning oil monitoring, proper oil heating, and routine maintenance to prevent future engine damage.technology proved useful in doing failure analysis when tested with real data from the MT. Ferimas Santosa ship during a three-year period.

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