

# Web Based Maintenance as Decision Support for Preventive Maintenance

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**Abstract** - Web based or computer based system can help the implementation of routine maintenance as well as ship preventive maintenance, it is because of with the web based or computer based system it can make the maintenance work faster and more efficient, because the information stored on database can be accessed easily and the information can be deliver quickly. Web based maintenance can be the solution of the maintenance problem that not efficient and can help on decision making.

Web based maintenance can be a guideline to do maintenance, with showing the frequency of maintenance and the maintenance activity instruction each component. Web based maintenance equipped with an access data of work hour each component, so it can be monitored on real time. This web also equipped with reminder system that combined with voyage plan, work hour of component and maintenance frequency, there is an explanation about the risk possibility when the maintenance cannot be done, with the risk level of each possibility. Beside that there is a printed work order form on the web to execute the maintenance that already approved. All of the information about work hour, maintenance frequency, components, maintenance record, maintenance activity, spare parts, etc, will be stored on the database that already provided before. The security of the web equipped with login page that filtered the user, so the web can be accessed by authorized person only.

Web based maintenance expected to increase the maintenance performance in order to faster, more efficient and more simple. Beside that it can help decision making to do the maintenance.

**Keywords** - web, maintenance, web based maintenance, decision making, database.

## I. INTRODUCTION

P.T. Tanto Intim Line is one of the biggest shipping company in Indonesia, with all of the fleet or ship that the company has and all of the different route, the realtime information about the condition of all the component. The information that given by the onboard crew will be used to make some planning about how and when the maintenance will be held. The maintenance process used to prevent failure of the components or system when the ship is sailing, so there is no disturbance when the ship is operating to transport their cargo. The main asset of shipping company is their ship, without their ships the business chain of shipping company will be useless. The ship operated by the propulsion system, with the propulsion system the ship can do the voyage or transport the cargo of its customer, so one of the important component of the ship it's the propulsion system of the ship.

Maintenance is one of the way to keep the availability of the asset, so there is no disturbance on the function of its asset. With maintenance the availability of the asset will increase, prevent the failure of the

component, reduce the cost for repairing because maintenance reduce the impact of failure component. Therefore, the maintenance process or procedure is one of important task for the company, so the company can provide better service for the consumer, with less downtime or problem.

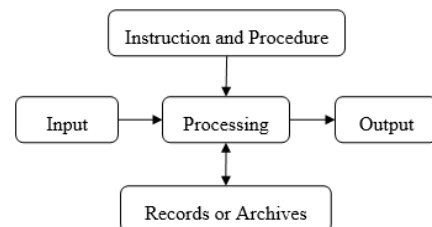
An efficient, planned and controlled maintenance could be executed properly, with the maintenance management that used by the companies provide better data archives system. But there are still some companies that do the transferring data or information using conventional paper process. The risk of human factor to conventional paper process compared to information.

## II. LITERATURE STUDY

### A. Management Information System

A management information system is an information system that provides output to a manager. The term 'manager' refers to decision-makers in organizations only, which is admittedly a somewhat narrow view of the concept [1]. A management information system normally used to manage all of the information to support the manager of the organization to make decision making, therefore a management information can help a lot with the decision making, because all of the information will be managed and stored in management information system, so it make easier to decision maker to make a decision based on the stored information.

The basic component of information system consists of several components, such as input data, data processing, develop procedure, and preparing output [2]. The basic component can be shown as figure below.

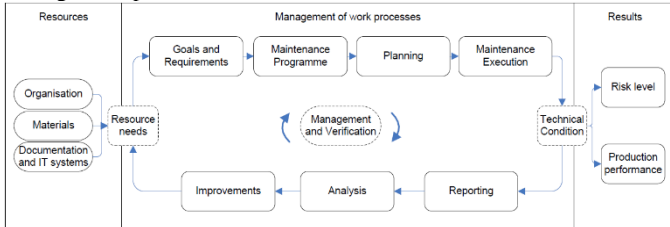


**Figure 1. Basic component of information system**

The basic component of information system design of how the information system works. Manually all of the component will be done by human being, but with the technology now on the component can be done using computer. Human only need to input the information and make some logical function so the computer can process information to make some output just like the develop expected. The computer can be used to process the information faster and much more than human being. Because human brain has a limitation to process all of the calculation or all of logical function, therefore computer can help human to accomplish their task with calculation or do the logical function.

### B. Maintenance Management Process

Maintenance is a maintenance activity accordance to the procedure by looking at the probability of a component or system damage or failure [3]. *Preventive maintenance* is a simple maintenance activity such as repairing, changing the component, setting the machinery, lubricating and another maintenance activity at downtime schedule that already measured with analyzing failure rate of the machine [3]. The preventive maintenance reduces the amount of reactive management process.



**Figure 2. Maintenance Management Process**

Flowchart on figure 2. show us about the basic maintenance management process from NORSOK STANDARD Z-008 [4]. In the flowchart above the management of work process begin on resource needs, the component or the system information included in resource needs, the information will be used for the maintenance programme. In maintenance programme we need to identify failure cause, failure pattern or failure mode, maintenance programme includes maintenance interval and written procedures for maintaining, testing and preparing the various component. A maintenance plan is structured by activity, procedure, and method. All of the plan basically need to consider based on the impact on production and HSE (healthy, safety and environment). Then the maintenance execution, maintenance execution as general is about giving work order according to the maintenance plan. The execution includes preparation, work permits, carrying out work and reporting mandatory information on work order. After the work order is done, the work order need to reported so the work order is closed if the work order done perfectly just as planned, and the reporting of work order will be used for analyzing to make some improvement for maintenance process if it's needed.

### C. Maintenance Management Software

There is several maintenance management software that already exist and well known among the companies. Each maintenance management software offers the different features of its software. The features of existing maintenance management software will be presented below.

#### 1) DNV GL Technical Ship Management

The features from DNV GL Software [5]

- centrally manage your fleet wide equipment and maintenance jobs
- define and schedule counter-/calendar-based and condition-based tasks
- categorize jobs and elements according to relevant criteria, such as critical, safety relevant, class relevant or origin
- prepare and document all planned and unplanned maintenance tasks performed
- automatically update stock counts in consideration of spare parts consumed for maintenance tasks
- keep running hours for each equipment item individually, regardless of where it is installed
- define different manual and automatic counters and counting directions
- attach digital forms, manufacturer's instructions, illustrations and integrated measurement records

#### 2) CMMS CWorks

**Table 1. CMMS Cwork Features**

No	Modules	Function
1	Master	Provides the coordination of the information. Define background information which will be used by other modules.
2	Asset	Provides the facility to record and manage your organization's asset and equipment.
3	Location	Provides the facility to record and manage your facility's physical location.
4	Work Order	Provides the ability to view and manage all maintenance activity.
5	Preventive	Preventive maintenance (PM) master and schedule specifies work to be performed based on elapsed time interval.

## III. METHODOLOGY

### A. Preparation

The preparation for this final project use the list of equipment and list of spare parts. The equipment will be sorted based on Germanischer Lloyd Rules of Renewal Survey on machinery section. So the equipment that not listed on Germanischer Lloyd Rules of Renewal Survey will not be used in this final project. The spare part list for the ship are acquired from the project guide of main engine and auxiliary engine that listed based on the request from the classification, and the requested quantity of spare parts from the classification. The spare part will be listed for each equipment.

### B. Data Analysis

The data analysis of this final project are naming equipment, task list, planning and creating work order. The code name will be given for each equipment to easier recognize each equipment, the code will be given using code format that created before. The code will give the information about the equipment class, system, and number of equipment.

The task list is about giving maintenance activity to each equipment based on work hour of each equipment. The different work hour will do a different maintenance activity. The maintenance activity will be given from maintenance manual book, maintenance instruction or generic maintenance concept, beside of the maintenance activity it will give the information about frequency of maintenance activity.

The consideration of maintenance planning is work hour, frequency maintenance, and condition of equipment. The voyage of ship will become the consideration for maintenance plan. To make maintenance plan all of the consideration will be analyzed using logical function to decide when the maintenance will be held. Besides that, the risk level of each activity become the consideration of the maintenance planning. The risk level of the activity will be created with risk matrix from Australian Standard 31000:2009 [6].

The maintenance planning will be carried out by work order so the maintenance activity can be held. Work order will be released if there are any maintenance activity that should be done at the exact time of maintenance plan. The standard for creating work order will be using standard from British Standard EN 13460:2002 [7].

### C. Web Development

The step of web development on final project are module, web interface, database and programming. The essential to create a web is a modules of web and the structure of the web itself, all of the information about maintenance management application such as Germanischer Lloyd Ship Management and CMMS (Computerized Maintenance Management System) will be used as reference for making module and web structure for final project, and from the maintenance management process from NORSOK Z-008.

The realization of web structure is to make web pages as web interface so the user can access the web. To make web interface the tool is Macromedia Dreamweaver 8 that support PHP, HTML, XHTML, etc., to design the web interface. The interface will be using PHP and HTML script that created in Macromedia Dreamweaver 8

To make the active or live web, the database used to store all of the information that needed to run the web. MySQL is a programming language that manage the information on the web database. PHP MyAdmin is a software to access, change, add, or delete database. The database will be connected to the web interface. To make a good database it begins with creating data flow diagram, so the relation between one database to another clearly seen. The result of database step will be providing the information that store on back-end of the web, the source of information is from the interface of the web.

The last stage is programming the web, the activity is to connect the database to the web display, so the user can access the information from database on the web pages. The other program is used to create some function to analyze the data, so the data will be analyzed and give the result to the user. The programming will be using Macromedia Dreamweaver 8 as web interface and PHP MyAdmin to access the database. Therefore, the web can run with all of the connection between the web pages and database, so the information from the database can be shown on webpages.

#### IV. DATA PROCESSING AND PROGRAMMING

##### A. Equipment and Spare Parts

The listed from the equipment will be given the code for each equipment. The function from its code is to give the information about the equipment so the equipment can be easily recognized by the employee and the worker. The format code for the equipment shown in the formula below,

Nomenclature for system:

AAA – BBB – CCD

Note:

- AAA = Group of equipment.
- BBB = Code of the system.
- CC = Code of the equipment.
- D = Number of equipment.

Nomenclature for equipment (without system):

AAA – BBC

Note:

- AAA = Group of equipment.
- BB = Code of equipment.
- C = Number of equipment.

##### B. Planning / Reminder System

The planning for maintenance activity will be done on the port while the ship does loading – unloading the cargo as stated by the crew of the ship itself. The maintenance should be done in the port it is to prevent the equipment fail when the ship sailing to the next port. The planning of maintenance will be using “if statement” from the maintenance frequency period, work hour of each component and the next voyage of the ship that come from the voyage plan of the ship. The “if statement” for planning the maintenance is shown on the formula below.

If Statement:

$IF (WH > (FM + NV), \text{Now, Later})$

Note:

- WH = Work hour for each equipment.
- FM = Frequency period of maintenance for each equipment.
- NV = Time for the next voyage from the current port to the next port.
- Now = The maintenance should be done in the current port.
- Later = The maintenance can be done in the next port.

The formula above is to decide when the maintenance should be done. So, if the work hour greater than the frequency plus next voyage, the maintenance should be done in the current port, otherwise the maintenance can be done in the next port. For the spare part for the equipment, in this final project it is assumed stored on the shipping company warehouse and some of the equipment stored in the ship itself, so if there are any problem with the spare part stock in the ship, the crew can call the shipping company to deliver the spare part to the ship. The web interface for maintenance planning can be shown on figure 3.

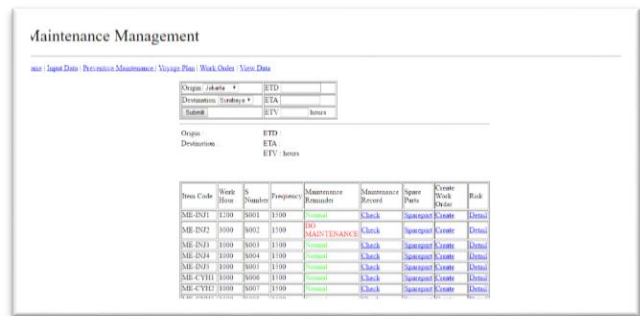


Figure 3. Reminder System Webpage

##### C. Risk

To determine the risk level will be using the risk matrix, and the consequences in this final project only use the operational consequences. The determination about likelihood and consequences level shown on Table 2 and Table 3.

Table 2. Likelihood Level

Category	Explanation
Almost Certain	Expected to occur in most circumstances, or often in the life of a vessel’s operation.
Likely	Probably occur in most circumstances but unlikely to occur often in the life of a vessel’s operation.
Possible	Might occur at some time, unlikely to occur to every vessel but may occur to a few vessels of a particular type.
Unlikely	Unlikely to occur but should be considered as possible.
Rare	So extremely remote that it should not be considered as possible unless exceptional circumstances exist.

Table 3. Consequence Level

Category	Work / Income / Reputation
Catastrophe	Operations halted, image / reputation is severely damaged.
Major	Major disruption to operations, temporary loss of income, image / reputation impacted.
Possible	Significant disruption to operations, image / reputation suffers.
Minor	Minor disruption to operations.
Insignificant	No adverse effect on operations.

The likelihood will be combined with consequence level to find the risk level on risk matrix from Australian Standard 31000:2009 [6] that shown on figure 4.

Ref. ISO 31000	Consequence				
	Insignificant	Minor	Moderate	Major	Catastrophe
Almost Certain	Moderate	High	Extreme	Extreme	Extreme
Likely	Moderate	High	High	Extreme	Extreme
Possible	Low	Moderate	High	Extreme	Extreme
Unlikely	Low	Low	Moderate	High	Extreme
Rare	Low	Low	Moderate	Moderate	High

Figure 4. Risk Matrix

The final result about risk detail that will be displayed on the webpage can be shown on figure 5.



Figure 5. Detail Risk Webpage

D. Features

The modules for the web will be referenced from several the existing maintenance management application. The modules that will be created on this web-based maintenance are:

- a. Manage equipment and maintenance activity.
- b. Manage spare part quantity.
- c. Record all of the breakdown equipment time.
- d. Keep running hour of each equipment
- e. Help decision making on maintenance, based on when the next stop of the ship and risk level.
- f. Digital form of work order.
- g. Maintenance Reminder System.

The modules or the features based on the basic maintenance management from NORSOK STANDARD Z-008, and several feature from the existing maintenance management application. The user of this web-based maintenance will be propose for:

- a. Educational
- b. Small company
- c. Web Developer

E. Web Design

To develop a web or program beside to decide how the programs will work, the work flow and information flow need to be develop, because without the workflow it's hard to create webpages on purpose. The workflow for this web shown on figure 6.

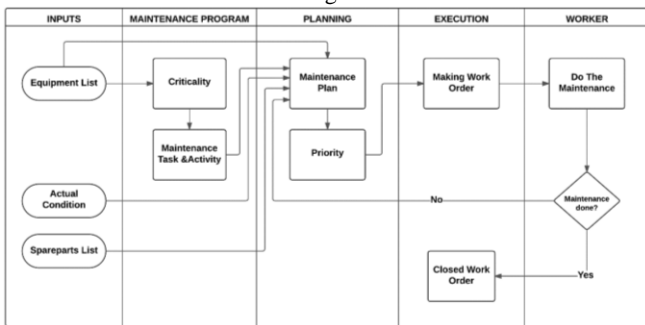


Figure 6. Workflow

The figure 4 shows the workflow, while Table 4.4 explain the information flow in this web based on the figure 6. The workflow

shows about what activity or what work that happen in this web, and the information flow show about what information that carry on from each activity to the other activity. The connection between the activity to the other activity and the information that collected or needed to do the next activity is shown on the table above. If the information of from the previous activity didn't complete it can cause the whole work of the web will be interrupted.

Table 4. Workflow Information

No.	Step	Activity	Information	Capture on
1	Equipment List	Input item list from machinery system.	Item name Item code Class System	Asset
2	Actual Condition	Input actual condition of each item.	Item code Work hour Status Notes	Input data
3	Spare parts List	Input spare part for each equipment	Spare part number Item name Item Code Spare part Quantity	Asset
4	Criticality	List all of critical item, based on critical level criteria by NORSOK Z-008.	Critical item	Database only
5	Maintenance Task & Activity	Make maintenance activity for each item based on maintenance manual book.	Item code Schedule number Maintenance activity Maintenance type Frequency time	Maintenance Activity
6	Maintenance Plan	Make maintenance plan on each item based on actual condition of each item. Make plan for failure work order	When the maintenance can be held.	Reminder System.
7	Priority	List of priority of maintenance plan based on requirement or work hours.	Work priority	Database
8	Making Work Order	Make work order based on schedule and work priority	WO number WOtype Work type Schedule number Task Number Priority Item code	Work Order

			Item status Description Employee Spare parts Created date Assign work order Requester work order	
9	Do The Maintenance	Do maintenance base on open work order by the worker	Work order status	Work Order
10	Closed Work Order	Close the finished work order.	Closed work order	Work Order

F. Web Structure

The function of web structure is to make sure the web that created on this project will be structured, so the connection between one page to other pages will be clearly seen on web structure. The web structure using Germanischer Lloyd Ship Management and CMMS as reference to create the web structure. The structure of the web will be shown on figure 5.

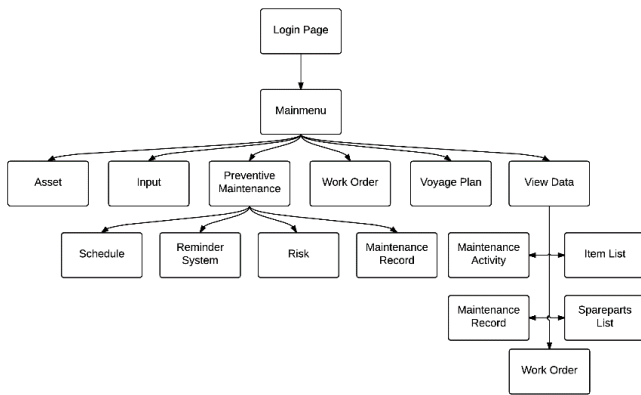


Figure 7. Web structure

The web structure that shown on the figure 7, give the information about the relationship between one pages to the other pages. The function of its webpages is to help the web developer and the user to access and to develop he web. The web structure designed just like the map of the web, that makes easier for user and web developer to navigate each web page. The function of each web pages can be shown on the table 4.

G. Database

There are two ways to store the information in the database, the first way is to input the information directly in the back-end of the web, the other way the user can input the information from the fron't end of the web. In this case, the first information will be stored to the database directly from the back-end of the web using PHP MyAdmin to manage the database in MySQL programming language. To create a good and organize database, the structure of the database is required. The connection between one information to the other information need to be seen as clearly as possible, so the user or the web developer can identify easily if there are any problem with the information or the database. The database structure can be shown on figure 8.

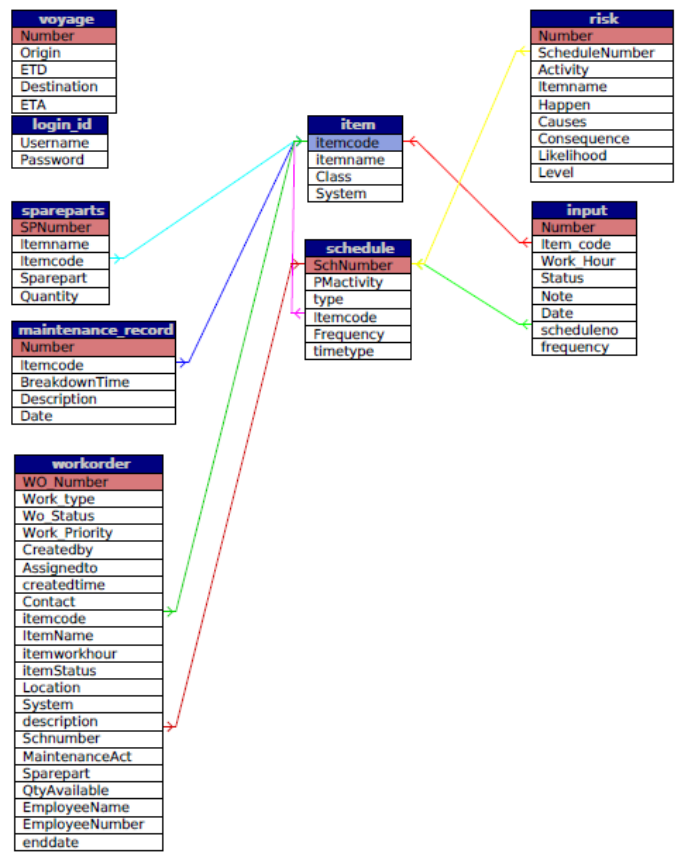


Figure 8. Database Schema

As shown on the figure 8, the relation between each table, the relation between each column represent how the information between one column to another in connected. The line shows about the connection between one column to another column from different table.

V. CONCLUSION AND SUGESSTION

A. Conclusion

Based on the result from this final project, the writer concludes several conclusions as mention below:

1. Web based maintenance provide the maintenance frequency with reminder system to make sure the maintenance can be held on the right time, so the overlapping maintenance time can be avoided.
2. To design decision support, the web based maintenance featured with reminder system that combined with voyage plan and work hour to make a recommendation when the maintenance time comes. To help decision making, there is a risk level and the consequence of each maintenance activity if the component fail, to help decision making.

B. Suggestion

The suggestion from the result of this final project for the next research are:

1. Need to add more features to make web based maintenance not only for maintenance purpose but also can connect with the another aspect of the ship and its company. Because maintenance will be the crucial aspect not only for the maintenance itself but also for the different aspect of the company.
2. Need to develop with another programming language beside of PHP and HTML, to make the web more alive and easier to be accessed.

## BIBLIOGRAPHY

- [1] Heijden, Hans Van Der. 2009. **Designing Management Information System**. Oxford University Press Inc., New York.
- [2] Scott, George M. 1986. **Principles of Management Information System**. McGraw Hill.
- [3] Ebeling, C.E. 1997. **An Introduction to Reliability and Maintainability Engineering**. The McGraw-Hill Company, Singapore.
- [4] **Risk based maintenance and consequence classification**. Norsok Z-008, 2011
- [5] DNV-GL. **Maritime Software Brochure**.
- [6] Australian Maritime Safety Authority. **Risk Management in The National System a Practical Guide**. Canberra city ACT 2601.
- [7] British Standard. **Maintenance – Document for Maintenance**. BS EN 13460: 2002.
- [8] Calder, Nigel. 1992. **Marine Diesel Engines Maintenance, Troubleshooting and Repair Second Edition**. International Marine Camden, Maine.
- [9] Compton, Peter. 1998. **Troubleshooting Marine Diesels**. International Marine Camden, Maine.
- [10] Delisle, Marc. 2012. **Mastering PHPmyadmin 3.4 for Effective MySQL Management**. Packt Publishing, Ltd.
- [11] Gupta, Hitesh. 2011. **Management Information System (An Insight)**. International Book House PVT. Ltd., New Delhi.
- [12] **Germanischer Lloyd Rules and Guidelines Edition 2013**.
- [13] Hove, Sue, & Booth, Donald S. 2006. **Macromedia Dreamweaver 8 Certified Developer Study Guide**. Adobe Press.
- [14] Powers, David. 2014. **PHP Solutions: Dynamic Web Design Made Easy Third Edition**. Apress.
- [15] Valade, Janet. 2010. **PHP and MySQL for Dummies, 4th Edition**. Wiley Publishing, Inc.
- [16] Wireman, Terry. 2003. **Benchmarking Best Practice in Maintenance Management**. Industrial Press Inc., New York.
- [17] Wireman, Terry. 2010. **Developing Performance Indicator for Managing Maintenance**. Industrial Press Inc., New York.