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Study of QR Code Technology Application for Monitoring Activity of Ship Planned Maintenance System

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Abstract

System and outfitting in a ship vary with different brands and treatment methods. These conditions can be an issue if the operator has undisclosed damages due to a lack of knowledge about the ship's maintenance records. An electronic planned maintenance system (ePMS) is a system that is currently used to collect the ship maintenance recorded data. However, the use of ePMS still has drawbacks. The appearance is less interactive, available information about the outfitting used in ships is limited, and the operator needs to search the outfitting manually with scrolling. This research aims to study the application of QR code technology for monitoring maintenance activities of ship systems and outfitting. This research was conducted based on field observation of ePMS, designing a QR code module for the ePMS application, developing algorithms, and creating programs for website and android based applications. In addition, trials of the application and calculation of the costs incurred for implementing the QR code method are also carried out. The distribution of questionnaires for practitioners accompanied the trial. Based on that, the implementation of QR code in ePMS can be applied, easy to use and facilitate the supervision of ship system and outfitting activities with a mean score of 4.39 or equivalent to strongly agree. The addition of the QR code module is costed IDR120,426,000.00, where the process of recognizing and searching for ship systems and outfitting to view maintenance plans and maintenance history on the ePMS application is enough by scanning a QR code.

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1. Introduction

As a ship is transported by sea, the hull, construction, and equipment equipped onboard have a helpful life due to ship operations, environmental impacts, and accidents [1]. Systems and outfitting on a ship are very diverse. The same outfitting sometimes has a different brand and treatment method. These conditions can risk of errors in maintaining a system and outfitting. In addition, sometimes, the maintenance of a ship's system and outfitting is carried out by the operator after it is known that a system and outfitting have been damaged due to a lack of knowledge about ship maintenance records [2]. The ship maintenance record data collection system currently in use is in the form of ePMS (electronic Planned Maintenance System) [3].

However, the use of ePMS still has several drawbacks. The application's appearance is less interactive because it does not display all types and information about the outfitting used on ships. Operators are still dependent on devices to determine the order and placement of ship outfitting. With the current application view, ship crews (both new and experienced) need a long time to find the outfitting they want to do manually [3].

Nowadays, QR codes can be implemented for monitoring activities for maintenance of ship systems and outfitting. QR codes can store large amounts of data, are efficient, easy to use, can be linked to specific pages or documents, are easy to update, and are considered safer [4 – 8]. In addition, the QR code can streamline supervision by reducing operational costs, physical storage, and simplifying the tracking of goods and information [9]. Therefore, the QR code is considered to make it easier to use and improve the application to make it more interactive.

Based on that, the researcher designed and implemented QR codes to monitor the maintenance activities of ship systems and outfitting. The implementation is expected to be easy to use, interactive, and facilitate the supervision of ship systems and outfitting activities to reduce the risk of error in ship maintenance.

QR code is a two-dimensional code that can store and convey information quickly [4]. The principle of a QR code is the same as a barcode [7]. The QR code is displayed in two dimensions (vertical and horizontal), while the barcode is shown in one dimension [4], [10]. QR codes can store information as much as 4,296 alphanumeric characters, 7,089 numeric characters, and 1,817 kanji characters [11]. In addition, the speed of delivering QR code information is faster than barcodes [5]. The

advantages of QR codes are multifunction, large data storage capacity, less paper usage, resistance to dirt and damage, readable from various directions at an angle of 360°, and the structure can be elongated [11]. However, QR codes have a weakness, namely the lack of understanding about QR codes. In addition, an additional application in the form of a QR code reader is needed, which must be added to mobile phones and tablets to access information from the QR code [5].

The structure of the QR code consists of a pattern finder, separator, timing pattern, alignment pattern, information format, data, error correction, and remainder bits [7]. The function of the pattern finder as an identifier is to identify the QR code and its orientation. The separator separates the pattern finder and data from the QR code. Timing pattern to determine the coordinates of the center of the QR code. The alignment pattern serves to correct non-linear QR code aberrations and distortions. The information format contains information about the error correction level and mask pattern. Data is used to store data. Error correction to store data about the corrector. Remainder bits only function as barriers, and there are no bits [5] [7] [9] [10].

QR code can be created by determining the capacity of the QR code and then encoding the data [12]. In addition, QR codes can be generated using the QR code Generator website and application. QR code reading requires devices that can scan such as scanners and cameras on mobile phones and tablets, and requires an additional application in the form of a QR code reader which can be downloaded via Google Play or the App Store [5].

Maintenance is a series of combinations of technical, administrative, and managerial activities that aim to maintain and repair goods to function optimally [2]. Regular maintenance is expected to extend the service life of the outfitting and restore near-perfect performance. Although in the end, it decreases past the tolerance limit and undergoes repair and even replacement [13].

Ship outfitting is all outfitting and instruments needed in the ship's operation, including the leading machinery, auxiliary engines, piping, deck outfitting, lifeboats, accommodation outfitting, water systems, rigging and so on. Outfitting can be grouped into four types, namely hull outfitting, machinery outfitting, accommodation outfitting, and electric outfitting [14].

An electronic planned maintenance system (ePMS) is one of the applications developed to make the PMS (Planned Maintenance System) system more effective. EPMS is divided into data entry in the field and data exchange [3]. The aim is to simplify the use of PMS and increase the efficiency of the PMS system by converting manual data formats to electronic ones. Changed data includes maintenance, authorization, planning, and reporting.

2. Methods

2.1. Observation of ePMS Usage

The observation of this research can be done by conducting ship survey and inspections in some docking facilities such as graving dock, multi pontoon floating dock [15], slipway with airbag, and slipway with cradle. Researchers use the ePMS application for the Camara Nusantara 6 ship which is currently docking at a shipyard in Surabaya. The use of the ePMS application starts from the wheel house. In the wheel house, researchers input data from maintenance inventory, such as a compass, clinometer, barometer and SART (Search and Rescue Transponder). Researchers find it difficult to find inventory items in the ePMS application because of the large number of inventory items on one ship.

Figure 1. Inventory located on the table in the wheel house

Next, the researcher headed to the pump room. Researchers have difficulty identifying the inventory in the pump room because in the ePMS application there is no general information about inventory and researchers are still unfamiliar with the pumps in the pump room if there is no name tag attached to them (Figure 2).

After the researchers changed the method for searching for inventory, from previously looking based on the inventory order in the ePMS application to looking for inventory in the application based on the location of the inventory, the researchers found difficulties because after the researchers were in front of the inventory to be treated, the researcher had to manually scroll to find the inventory in the app without the help of the search feature (Figure 3).This causes the inventory search process to take more time. After using the ePMS application directly in the field, researchers found several weaknesses in the application. A brief explanation of the shortcomings of the ePMS application is listed in Table 1. This is what underlies the researcher to add QR code technology to the ePMS application to make it easier to search and identify inventory.

Figure 2. Pumps in the pump room

Figure 3. The current view of the ePMS app

Table 1. Weaknesses of ePMS application in several aspects

Aspects	Weakness
Interactivity	Equipment / inventory search is still manual scrolling (impractical).
	Searching and getting to know the equipment/inventory takes quite a while.
Feature	There is no general information regarding equipment/inventory.
	No information about the room.

With these shortcomings, researchers want to optimize the interactive side of the current ePMS application by adding the QR code technology feature. It is hoped that the addition of the QR code module can increase the value of the ePMS application, especially in terms of its interactivity of the ePMS application.

2.2. QR Code Module Design in the ePMS Application

In short, this QR code module is an addition to the existing application, namely the ePMS application. In another research, research about ship's application based on web was already conducted by Samuel in 2014 [16]. The subject is a

ferry passenger ship in Merak-Bakauheni. Therefore this research is making the repair schedule application only. Based on that, the researcher made the ePMS application with the QR code. The QR code module is added to the position before " Planned Maintenance from the Form Builder" , so the diagram in Figure 4 turns into the diagram in Figure 5.

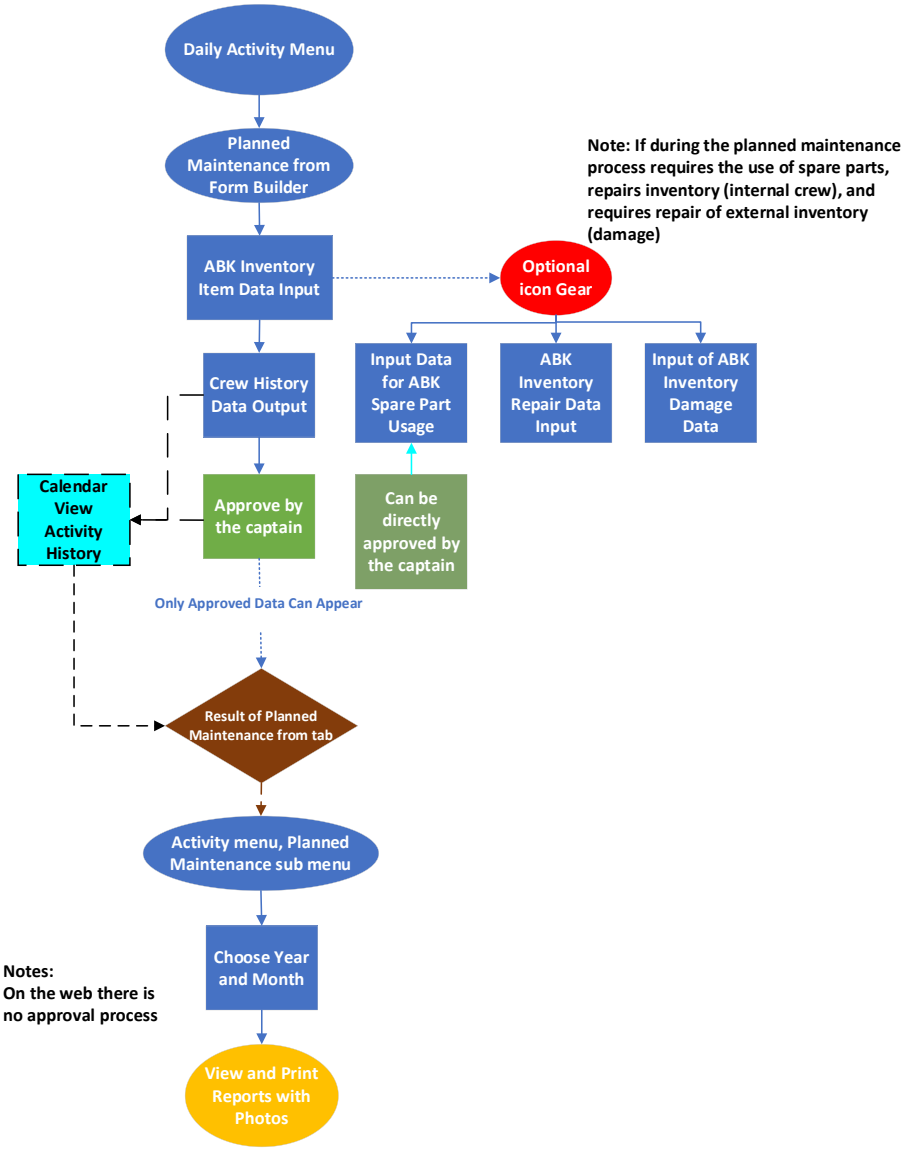


Figure 4. The ePMS current diagram

In this study, the position of the module is placed before the input of the inventory item data as illustrated in Figure 5. The reason for placing it in this position is because this position is the beginning of data exchange in the ePMS application. The QR code module is a tool for searching inventory on the ePMS application. From the QR code module, later the user will be assisted in finding inventory to be treated. In addition, the QR code can also access position data or rooms on a ship. The contents of the room are photos of corners of the room and photos of the location of the inventory as well as a list of the inventory in the room. From this room, you can directly access the inventory for maintenance. This function has already applied in the last research which run the QR Code technology to monitor the ship production processes [10].

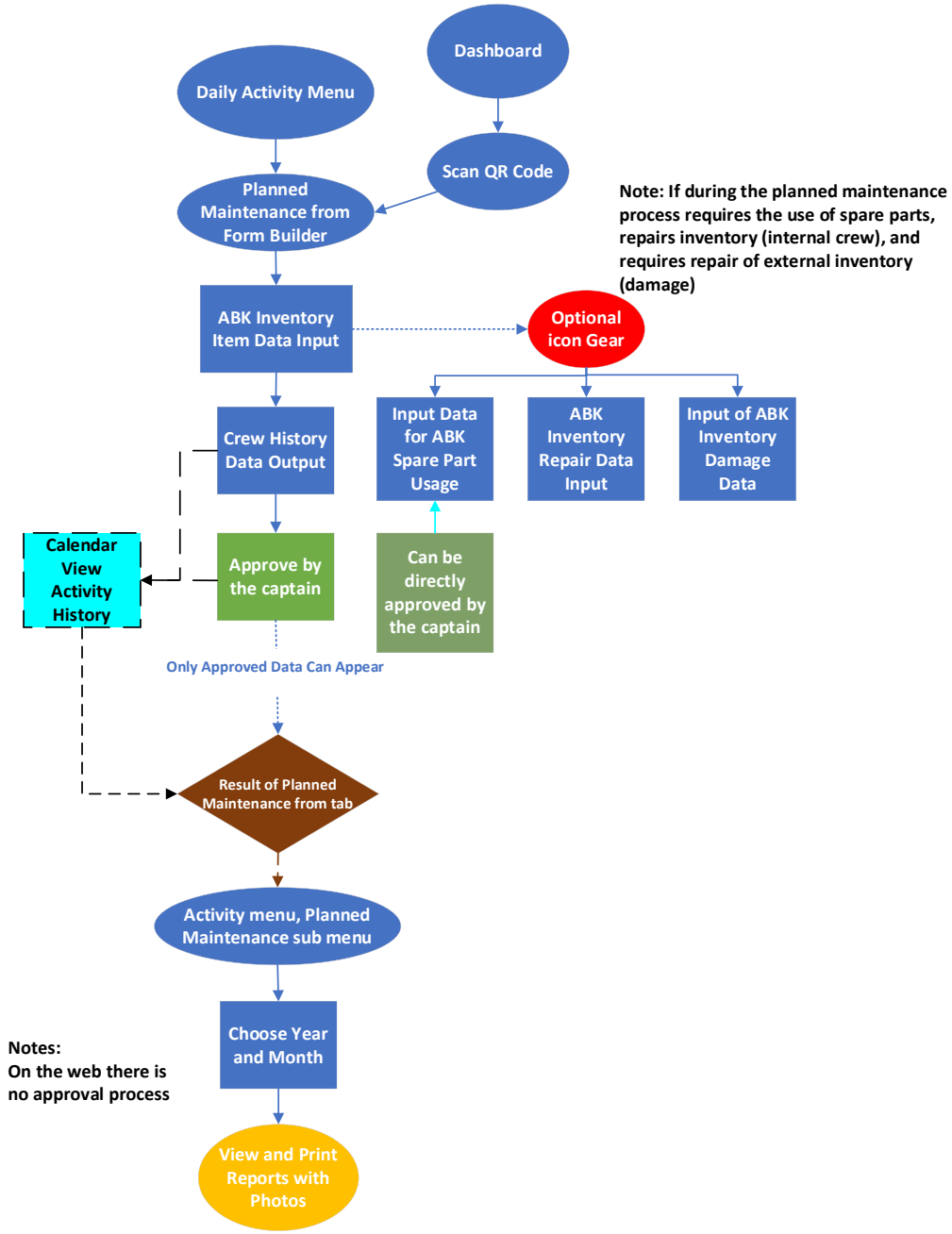


Figure 5. The ePMS diagram after adding the QR code

2.3. Design of Algorithm and Making Application Programs

2.3.1. Overview of Application Programs

The QR code is used with the aim of shortening the search time and recognition of inventory data in the android application. From the initial search manually by scrolling the inventory list (Figure 6), to going directly to the destination inventory as shown in Figure 7.

The use of the QR code starts with the admin entering the required data such as inventory data, spare parts data, room data and inventory maintenance needs form, which then the admin generates a QR code. Furthermore, after the QR code is generated, the QR code is printed and pasted on each inventory, spare parts and room by the maintenance department. Then the affixed QR code can be accessed by the ship's crew via the android application for the inventory selection shortcut in the android application. In addition, it can also be used to check the history of maintenance that has been carried out on the inventory. The flow of using the QR code will be explained in the form of a diagram which can be seen in Figure 8.

When generating a QR code, the coding used to access inventory maintenance in the Android application is converted into a QR code. One of the coding generated in this study is shown in Figure 9. The QR code is affixed to the Table Type Magnetic Compass with the scan results shown in Figure 10.

The data displayed after scanning the QR code are the Inventory Name, Inventory Brand, Model, Name of the Maintenance Form used, Class, Serial Number, Year of Manufacture, Location of the Inventory placed, maintenance form for planned activities (daily, weekly, monthly, yearly and other) and Activity History. In addition to inventory data, information about rooms and spare parts can also be accessed by scanning a QR code. The information displayed about the room is the photos in the room and the inventory list in the room.

Figure 6. The application before adding the QR code module

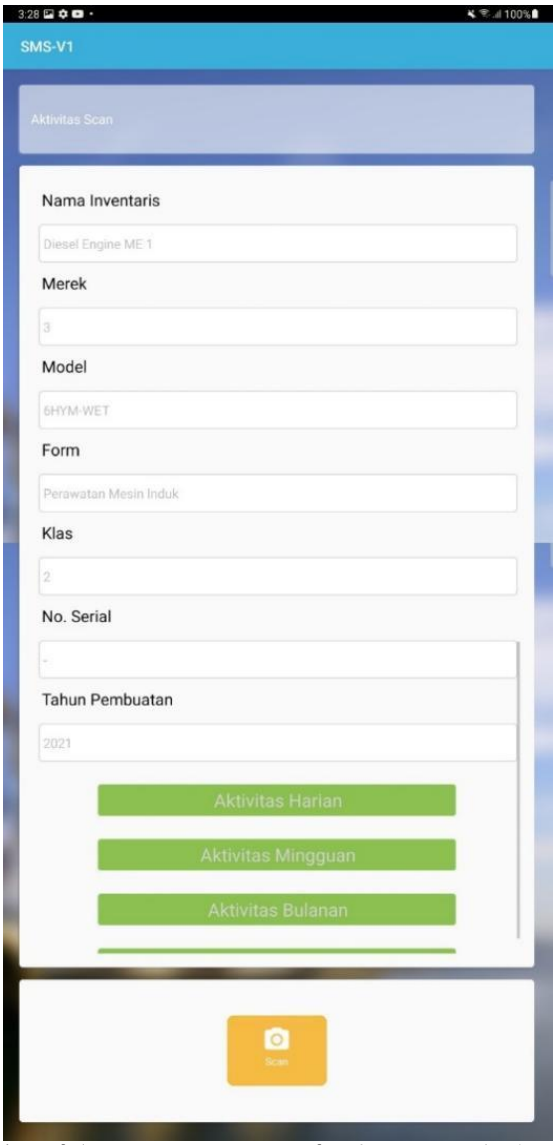


Figure 7. Display of the treatment menu after being searched using a QR code

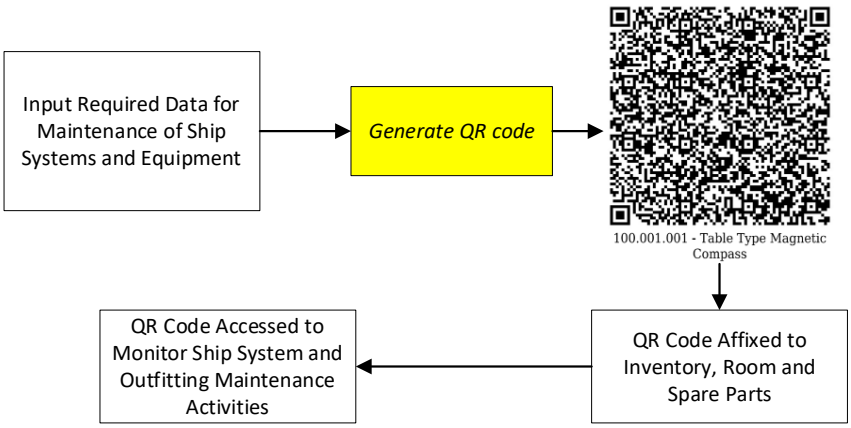


Figure 8. Flow of QR code usage

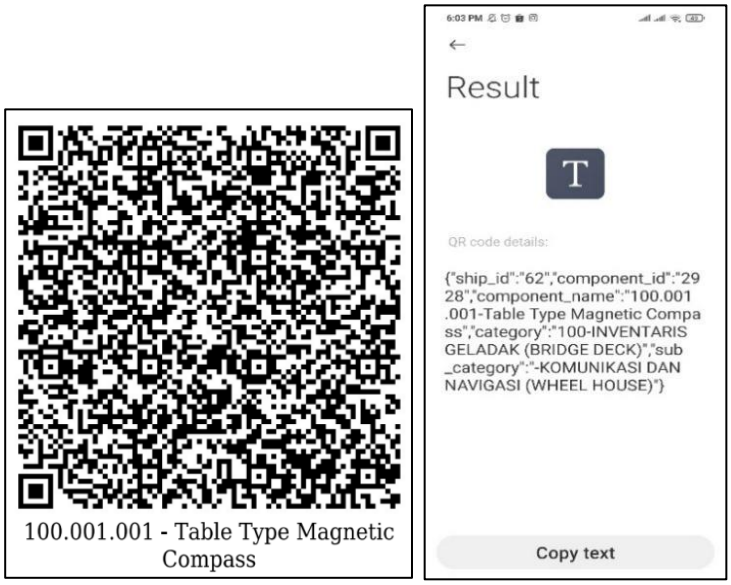
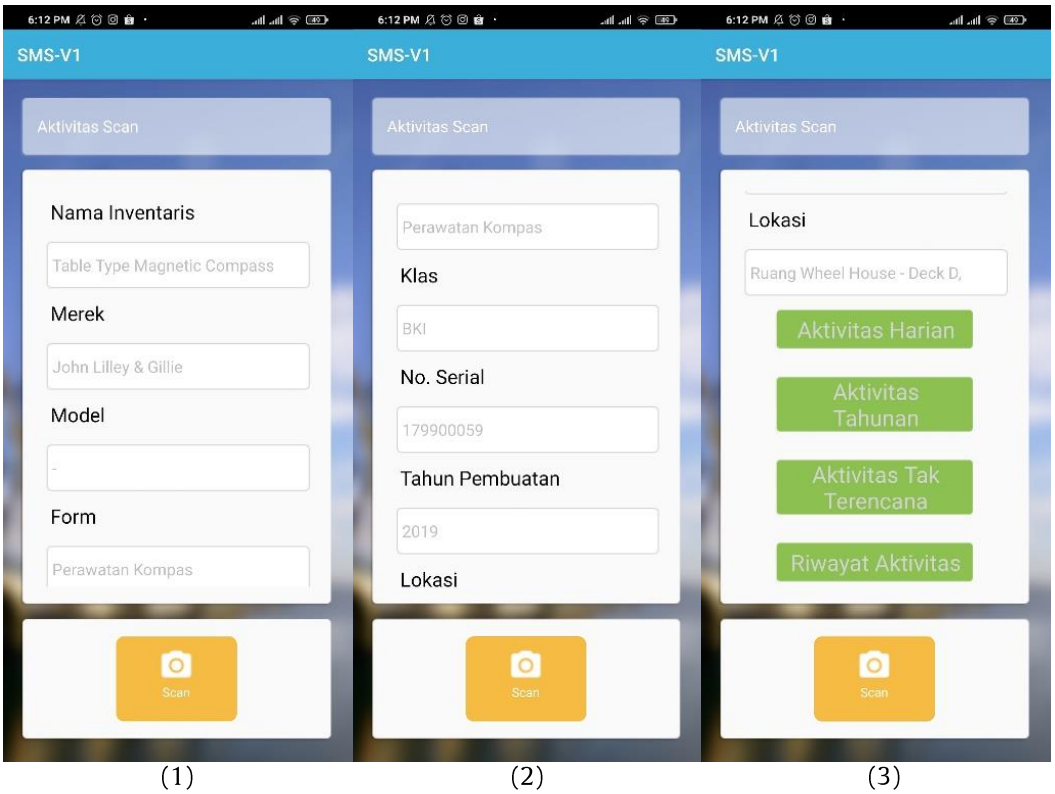


Figure 9. Coding generated into QR code



(1) (2) (3)

Figure 10. The display after the QR code is scanned by the android application

2.3.2. Website Application

In the screenshot of the application usage, this simulation starts from an admin who inputs inventory data, ship data and maintenance forms, and generates a QR code through the website. To access the website application, the user uses the address http://sms.ditlala-epms.com/.

1. Login Page

The login page is the very first page when a user wants to use the system. On the login page, the user simply fills in the username and password that was given at the time of registration (Figure 11).

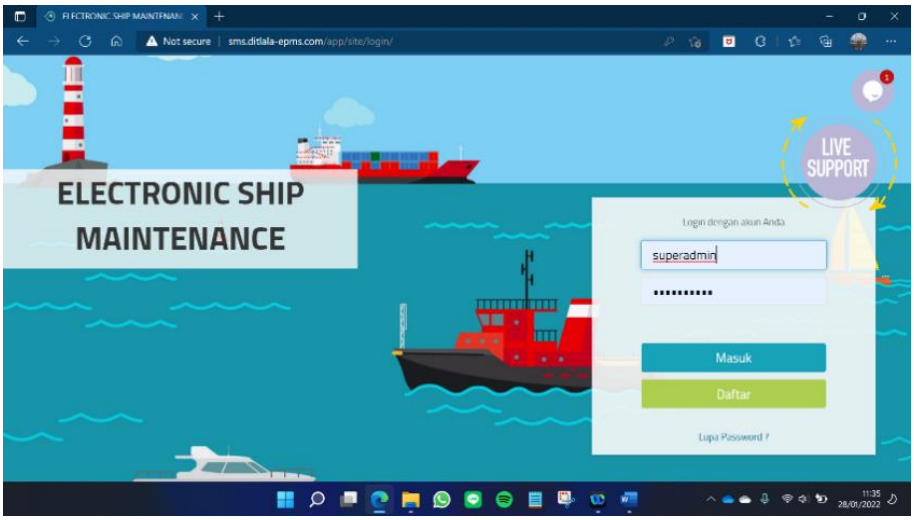


Figure 11. Login display when you want to use the system

2. Dashboard Page

After logging in, the user will get a display like in Figure 11. The system will display a dashboard page which is the main page of the website application system. If the cursor is moved to the left of the screen, a menu will appear that will be used in the monitoring system for ship equipment maintenance activities, which is shown in Figure 12.

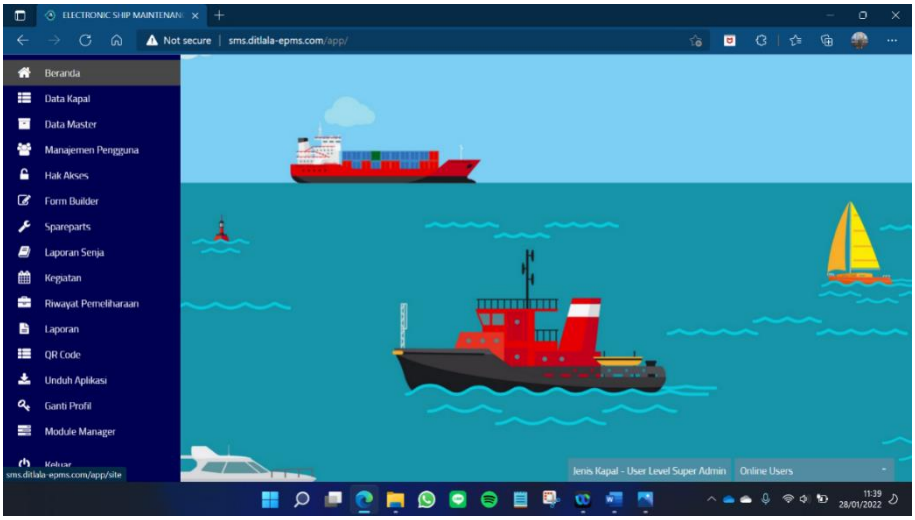


Figure 12. Display menus in the system

3. Dashboard Page

After entering the required data, the user can generate a QR code to be affixed to the inventory, spare parts and space on the ship. Later, the QR code will be scanned before the ship's crew performs maintenance on ship equipment or uses spare parts. In addition, the QR code used for the room can be useful for checking what equipment or spare parts are in the room. To access the QR code that will be used, you can select the QR code menu.

After selecting the QR code menu, the user will find a display like in Figure 13. In Figure 13, there are ship data that have been entered previously. The ship's QR code data displays the IMO Number, Ship Name, Ship Type and access options to the QR code you want to generate.

In the QR code inventory menu, a list of inventories contained on the ship will appear. In this view, there is a sort of Category, Sub Category and Name or Code that can be entered. Users can also generate the desired QR code by using "Search".

There is also a feature to display all QR codes from the inventory on board by clicking " Print QR Code Ship Inventory" which will add a new browser tab as shown in Figure 15. If you only want to generate a QR code from each inventory, you can click here. "QR Code" which will appear as shown in Figure 14.

To generate a room QR code, it looks the same as previously described. There is no difference in the choice of buttons or appearance. The difference is only in the content of the QR code.

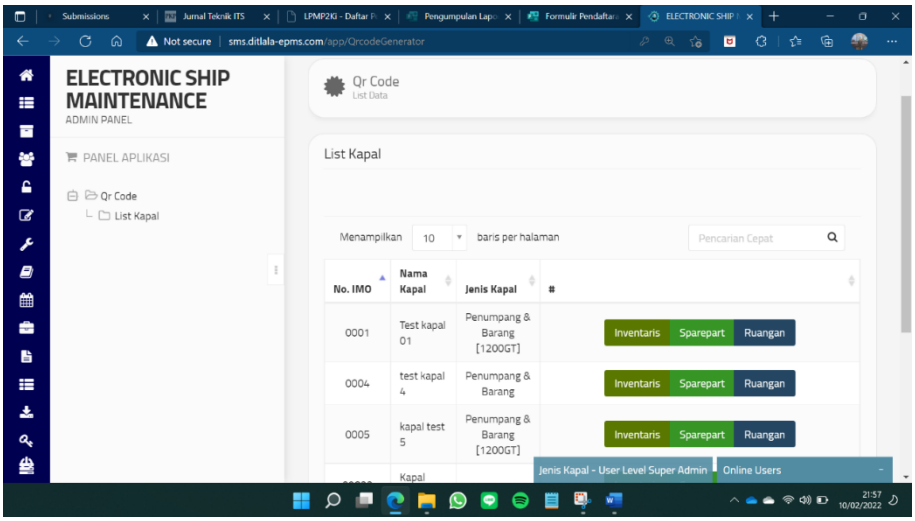


Figure 13. QR code menu display

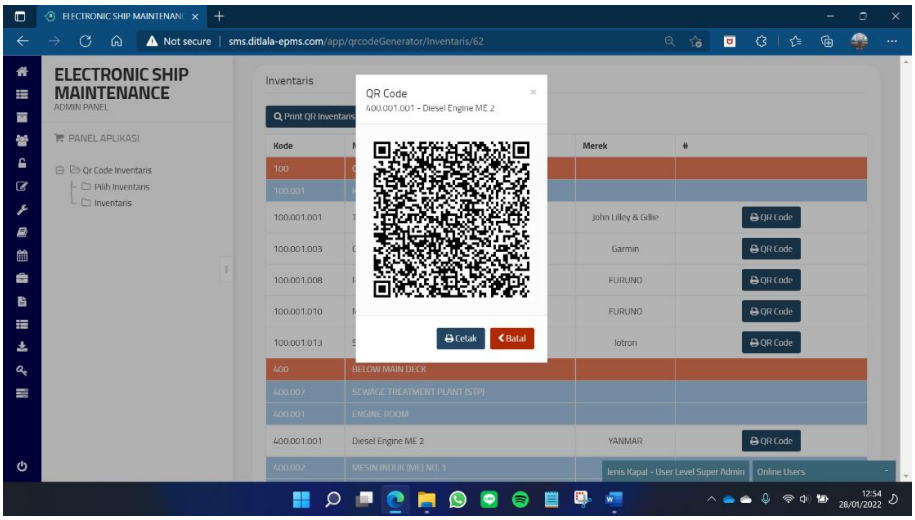


Figure 14. Display of generated QR code on an inventory

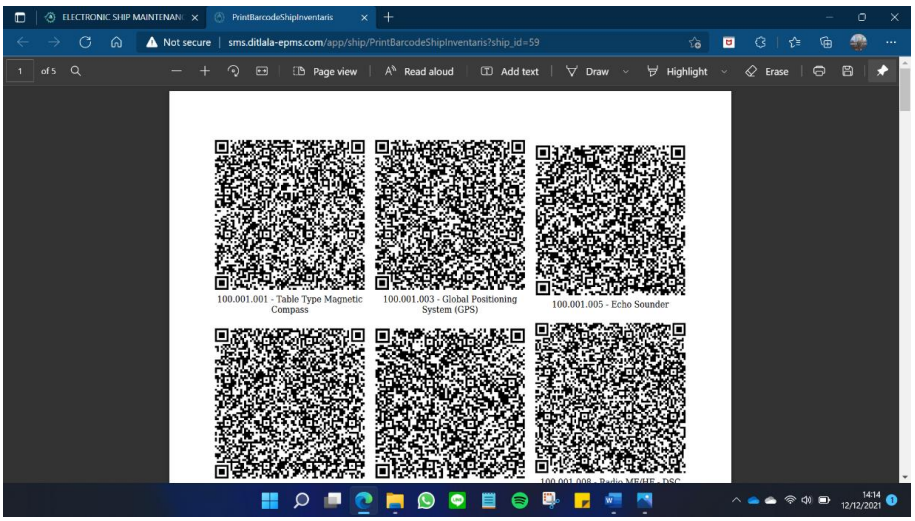


Figure 15. Generate QR code display for all inventory

2.3.3. Android Application

In the screenshot of the application usage, the simulation starts with the user entering maintenance data, viewing the contents of the ship's room, and viewing the history of maintenance activities.

1. Login Page

The login page is the first page when the user wants to use the system. On the login page, the user simply fills in the username and password that was given at the time of registration. The display is shown in Figure 16. And if you have logged in, the application will be synchronized by itself to prepare all the data to be displayed in the application.

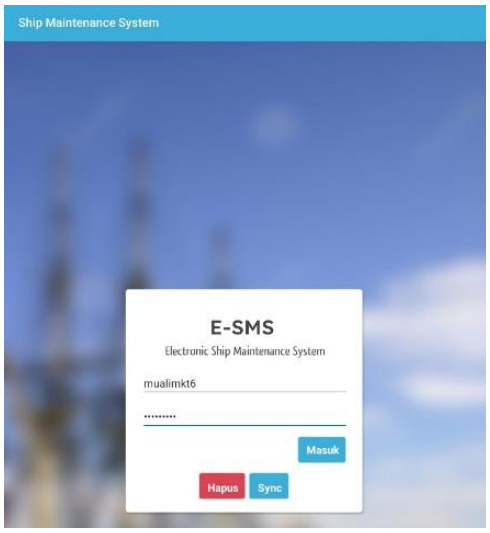


Figure 16. Display login on android application

2. QR Code Scan Page

After selecting the QR code menu on the dashboard, the user will be faced with a display as shown in Figure 17. In the Scan QR code display, the user must adjust the smartphone camera position so that the QR code can be scanned properly.

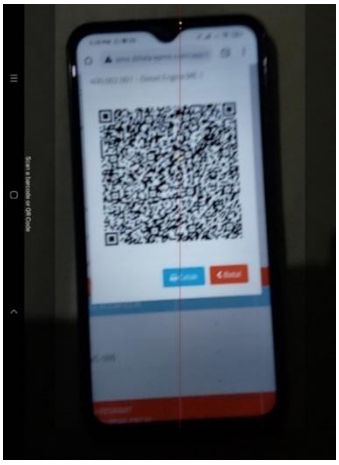
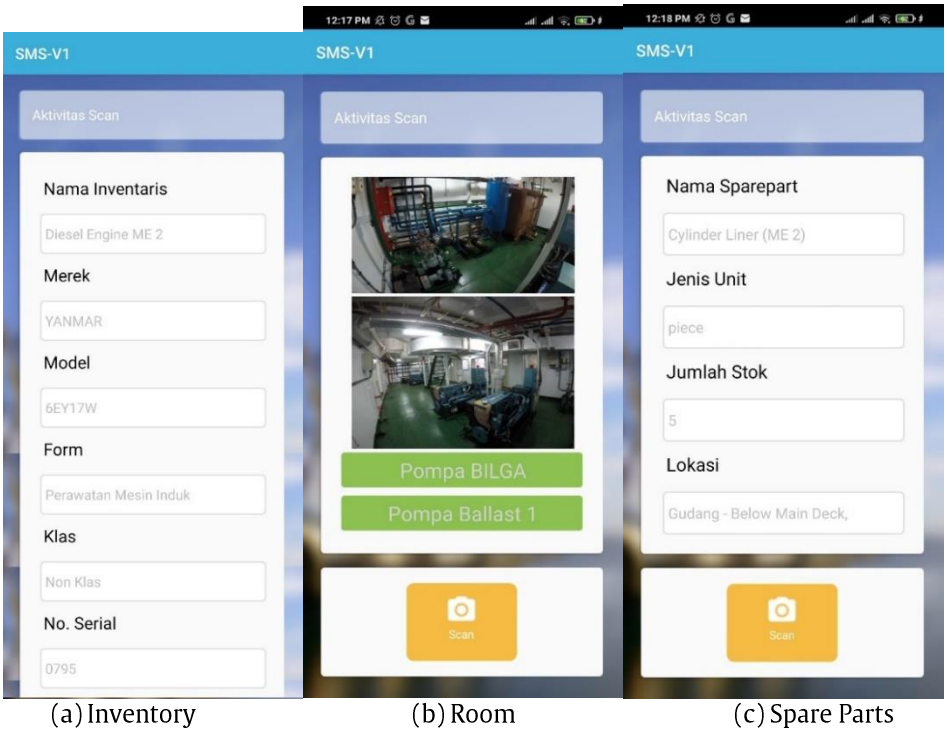


Figure 17. Display when scanning QR code



(a) Inventory (b) Room (c) Spare Parts

Figure 18. Display after scanning QR code

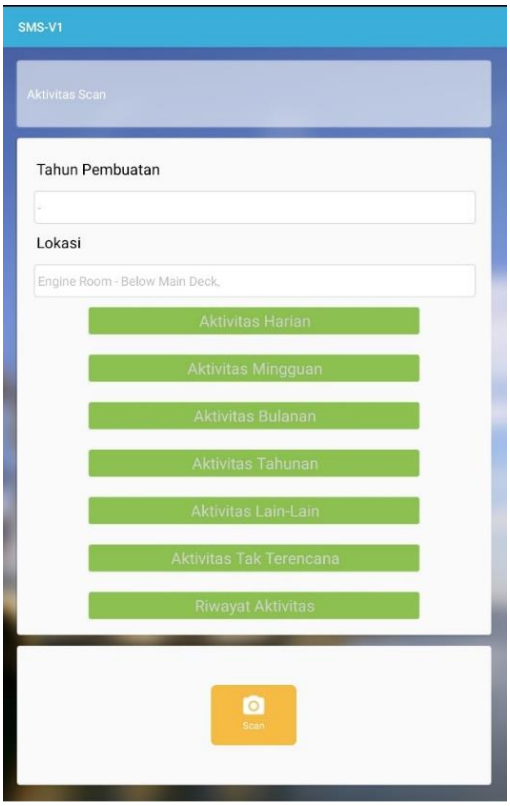


Figure 19. Display of maintenance activity types

3. Results and Discussion

3.1. System Comparison

With the addition of a QR Code module, it will be compared to the current system [3]. The following compares the current application with the QR Code as shown in Table 2.

Table 2. Comparison of current ePMS applications with QR Code

Current Application	Application with QR Code
Equipment / inventory search is still manual scrolling (impractical).	Practical, because it is enough to scan the QR code to search for equipment / inventory.
Searching and getting to know equipment/inventory takes a long time.	Cuts the search and recognition time of equipment / inventory, because after scanning the QR code, the application goes directly to equipment / inventory.
There is no general information about equipment / inventories.	There is general information about equipment / inventory.
There is no information about the room.	There is information about the room through photos and equipment / inventory lists.

3.2. Verification Test

The QR code module in the ePMS application can be used properly. Furthermore, system verification is carried out with a questionnaire. The list of questions from the questionnaire will be written as follows:

Q1 Is the display on this system attractive enough?
Q2 Is the application with the addition of the QR code module easy to operate?
Q3 Does this QR code module speed up the search for existing ship systems and equipment?
Q4 Is this QR code module able to help you in identifying ship systems and equipment?
Q5 Is this QR code module able to help you as a whole in the application for monitoring activities of ship equipment and system maintenance?
Q6 Does this QR code module need to be implemented in the current monitoring application for system maintenance activities and ship equipment?

In filling out the questionnaire, 3 (three) respondents were conducted. Based on the questionnaires that have been filled in by the respondents, the following results are obtained:

Based on the results of questionnaires that have been filled out by respondents from application users, an average rating of 4.39 is obtained with the category of strongly agreeing that the ePMS application with the addition of QR Code technology can be applied to the supervision of ship equipment and system maintenance activities.

Table 3. Recapitulation of the results of the questionnaire

Questions	(1)	(2)	(3)	(4)	(5)	Mean
Q1				2	1	4.33
Q2				2	1	4.33
Q3				1	2	4.67
Q4				2	1	4.33
Q5				1	2	4.67
Q6				3		4
Mean						4.39

Note: (1) Strongly disagree; (2) Disagree; (3) Hesitate; (4) Agree; (5) Strongly agree.

3.3. Costs

Costs are incurred based on the activities carried out for this research [17] [18]. All costs are procurement costs for adding the QR code module. Details of each cost can be seen in Table 4.

Table 4. Costs associated with adding the QR code module

No	Items	Number of items	Fee (IDR)
1	Services for adding QR code modules for Website (*includes programmer fees)	1	5,000,000
2	Services for adding QR code modules for Android (*includes programmer fees)	1	5,000,000
3	Application training fee for 50 people (IDR2,000,000.00 / pax)	50 pax	100,000,000
4	Print stickers (IDR63,000.00 / m^2)	2 m^2	126,000
5	Acrylic Print (IDR15,000.00 / *piece*)	20 *pcs*	300,000
6	Attachment QR code service on one ship	1 pax	10,000,000
	Total Fee (IDR)		**120,426,000**

4. Conclusion

After adding the QR code module to the existing ship equipment monitoring system, the following conclusions can be drawn:

a. The current condition of the ship maintenance system and equipment supervision system currently still has shortcomings in terms of application interactivity. Where in the current appearance of the ePMS application, ship crews need a long time to search for equipment names manually (scroll) first without the help of search. The ePMS app does not currently display general information regarding equipment/inventory either. Furthermore, the ePMS application also does not display information about the rooms and spare parts on board.
b. The addition of the QR code module to the ePMS application is carried out through the field observation stage, QR code module design, mock-up design, application module coding, module testing, analysis and discussion.
c. With the addition of the QR code module for the ePMS application, ship crews can now search for inventory / equipment more quickly and accurately than manually searching for inventory / equipment names in the previous ePMS application. Inventory / equipment data appears by simply scanning the QR code attached to the ePMS application, which is added to this QR code module. Inventory that has been affixed to the QR code can provide information about inventory specifications and also a list of maintenance to be carried out as well as a history of maintenance activities that have been carried out previously. In addition, with the addition of the latest QR code module, there is also supervision for rooms and spare parts that did not exist in the previous ePMS application.

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