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# Implementation of a QR-Code-Based Digitalization System for Technical Maintenance in the Workshop of PT. Tonasa Line

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**Abstract**

The effective operation of ship machinery heavily depends on consistent maintenance and the availability of precise technical information. However, traditional methods relying on printed manuals are prone to challenges such as damage, loss, and slow access, leading to inefficiencies in workshops. This research addresses these issues by implementing a QR-Code-based digitization system for technical maintenance information at the workshop of PT. Tonasa Line. Using the Rapid Application Development (RAD) method, the system was designed to provide quick and reliable access to essential technical data, including operational standards, machine specifications, and maintenance instructions. By integrating QR codes, the system ensures that technical information is accessible via mobile devices, enabling faster maintenance processes and minimizing downtime caused by manual errors or missing documentation. The results demonstrate significant improvements in the speed, accuracy, and efficiency of maintenance workflows, highlighting the system's potential as a scalable solution for maritime and industrial applications. This research contributes to the modernization of workshop operations by showcasing how digital transformation can overcome longstanding challenges in accessing and managing technical data.

## 1. Introduction

The operational efficiency of ship machinery significantly depends on routine maintenance and the availability of accurate technical information [1], [2], [3]. In maritime industries, the loss, damage, or inaccessibility of critical maintenance data often hampers operations, leading to delays, increased costs, and potential safety risks [4], [5]. Recent studies highlight that inefficient management of maintenance documentation not only increases downtime but also raises the risk of accidents and unplanned repairs, causing substantial economic losses for maritime operators [6],[7]. The PT. Tonasa Line, a leading provider of cement transport services in Eastern Indonesia, has become increasingly apparent, particularly in its workshops and during onboard maintenance activities.

Traditional methods of storing technical data rely heavily on physical manuals, nameplates, and documents, which are prone to degradation, misplacement, and illegibility due to environmental factors such as corrosion, wear, or water exposure [8], [9]. Such limitations frequently disrupt maintenance processes, causing

inefficiencies in accessing vital information for ship repairs and part replacements. As summarized in Table 1, key challenges observed in the current data management practices at PT. Tonasa Line includes missing or damaged manuals, illegible technical nameplates, and manual data retrieval processes that increase time and labor costs.

**TABLE 1.** Challenges in Traditional Maintenance Data Management

| Challenge | Impact |
|---|---|
| Missing or damaged manuals | Delays in maintenance and increased downtime |
| Illegible technical nameplates | Difficulty in identifying machinery components |
| Manual data retrieval processes | Higher time and labor costs |

Given these constraints, the adoption of advanced digital tools, such as Quick Response (QR) codes, offers a transformative solution. Originally developed by Denso Wave in 1994, QR codes have gained widespread adoption across diverse industries by enabling rapid access to large volumes of encoded data with minimal infrastructure requirements [10], [11], [12]. Recent studies demonstrate that QR-Code technology effectively enhances data retrieval speed, accuracy, and user interaction in sectors including manufacturing, healthcare, logistics, and transportation. Their capacity to store comprehensive technical information, such as machinery specifications, operational standards, maintenance logs, and spare parts inventory, makes QR codes an ideal choice for modernizing maintenance workflows and reducing reliance on vulnerable physical documents [13].

This study aims to implement a QR-Code-based digitization system tailored to the maintenance needs of PT. Tonasa Line. Using the Rapid Application Development (RAD) methodology, the research focuses on designing and deploying a system that ensures quick and reliable access to technical information via mobile devices. This approach not only simplifies the data retrieval process but also minimizes the risks of losing or damaging physical documents. Additionally, the research significantly contributes to improving operational efficiency by reducing maintenance downtime and errors, enhancing data accuracy, and promoting digital transformation in maritime maintenance. The developed system offers a scalable and replicable solution that can be adapted to other industries facing similar data management challenges.

The proposed QR-code system follows a streamlined process, as illustrated in Figure 1. This diagram demonstrates how users scan QR codes attached to machinery or equipment to retrieve relevant technical data stored on a centralized server. Such a system bridges the gap between traditional manual processes and the growing demand for digital transformation in the maritime sector.

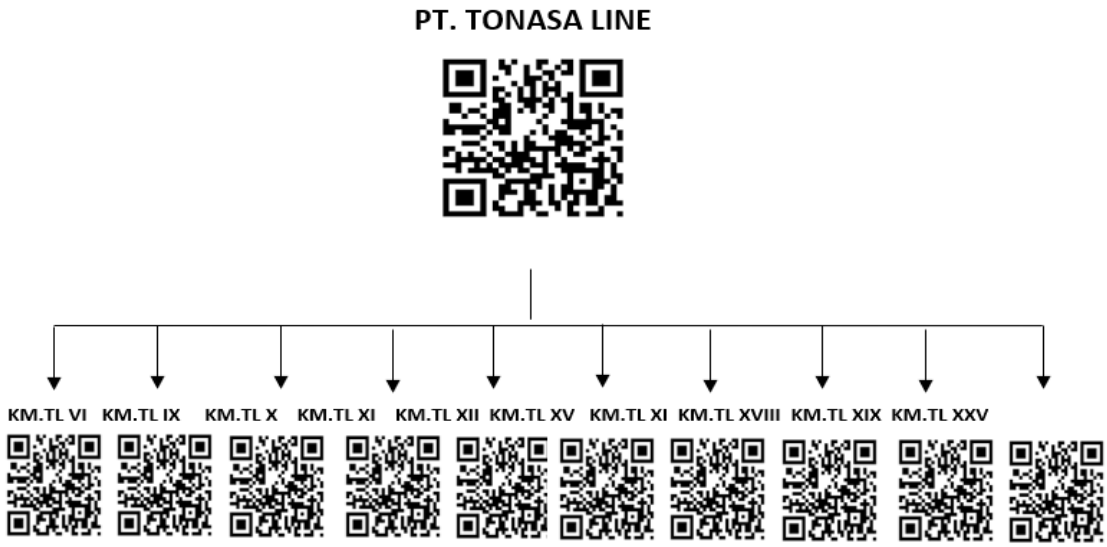


**FIGURE 1.** Workflow of QR-Code-Based maintenance system

The importance of this research extends beyond operational improvements at PT. Tonasa Line. It contributes to the broader discourse on integrating digital solutions in maritime industries, offering a replicable framework for addressing similar challenges in other sectors. By demonstrating the efficiency and scalability of QR-code technology, this study emphasizes its potential to revolutionize maintenance practices and ensure sustainable operations in a competitive industrial landscape.

## 2. Research Methodology

The success of any digital transformation project lies in adopting a structured and user-focused approach. In this study, the Rapid Application Development (RAD) methodology was chosen to ensure the timely and iterative development of a QR-Code-based system tailored to the needs of PT. Tonasa Line [19]. This methodology is particularly effective for projects that require constant user input and quick prototyping to address real-time challenges in accessing technical maintenance information.

The primary goal of this research was to replace conventional data retrieval methods prone to inefficiencies and errors with a streamlined digital solution. The development process involved multiple phases, starting with understanding user needs and progressing to system testing and validation. By incorporating a combination of qualitative and quantitative research methods, this study ensured that the proposed system not only met technical requirements but also addressed the operational pain points of technicians and crew members. The following sections describe the research design, data collection techniques, system development process, and validation steps.

### 2.1 Research Design

This research was conducted from March to October 2024 at PT. Tonasa Line's workshop and on board its fleet. The study focused on identifying existing challenges in technical data retrieval and designing a system to improve accessibility and efficiency. Key stakeholders, including workshop technicians and ship crew, were actively involved throughout the research process to ensure the system met their practical needs.

### 2.2 Data Collection Techniques

The implementation of the QR-Code-based system resulted in significant improvements in several key areas. Notably, the average time required for data retrieval drastically decreased from 15 minutes to less than 2 minutes, enhancing overall maintenance efficiency. Additionally, the system effectively minimized manual errors associated with outdated or damaged documentation, contributing to greater accuracy in technical data

handling. User satisfaction also saw a substantial increase, with more than ninety percent of workshop staff reporting improved workflow efficiency and ease of use.

2.3 System Development

The system development followed the structured phases of the RAD methodology:

1. **Requirement Planning**: mandated the precise definition of critical technical information, including machinery specifications and operational standards, for ship maintenance. Simultaneously, user demands emphasized a mobile-accessible system to ensure the rapid retrieval of data by field personnel.
2. **User Design:** this phase involved the iterative development of initial QR-code interface prototypes to gather valuable feedback and suggested improvements from key stakeholders. Concurrently, visual diagrams such as use case and activity diagrams were generated to accurately model the system's workflow, with the resulting proposed simulation further illustrated and detailed in Figure 2.

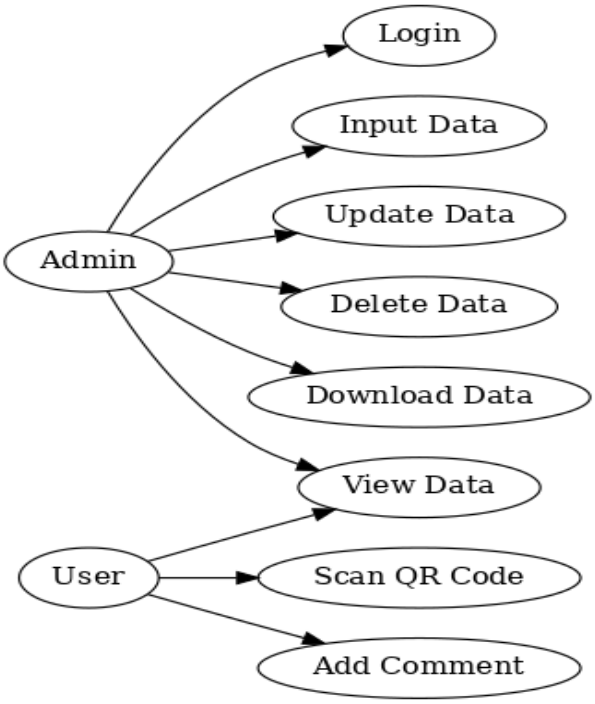


**FIGURE 2.** Simulation result

3. **Development and Testing:** this phase was executed through two primary actions. The system's construction was realized utilizing conventional web technologies, specifically PHP, HTML,] and CSS. Subsequently, iterative testing was performed employing the black-box method to rigorously validate the system's performance and ensure the consistently accurate retrieval of data.

2.4 System Features

The developed system incorporates several distinct features designed to address the identified operational challenges. Digital Accessibility is achieved through QR codes affixed directly to machinery, enabling maintenance personnel to gain instant access to critical technical data via mobile devices. This digital integration is supported by a Centralized Database, which functions as a single, authoritative repository for all essential documents, including maintenance logs, manuals, and spare parts information, thereby eliminating reliance on scattered physical documentation. Furthermore, the architecture provides Cross-Platform Compatibility, ensuring the system is equally accessible and functional across various devices, such as

smartphones, tablets, laptops, and desktops, which guarantees flexibility across diverse operational environments.

### 2.5 Testing and Validation

Testing constituted a critical stage to ensure the system successfully fulfilled both user expectations and stringent operational requirements. This evaluation focused on three primary aspects: assessing the Data Retrieval Speed—specifically, the time required to access information following a QR code scan; verifying the System Accuracy by confirming the correctness of retrieved data across different machinery types; and finally, measuring User Satisfaction through collected feedback from technicians and crew regarding the system's overall ease of use and effectiveness.

By combining the RAD methodology with extensive stakeholder involvement, this research successfully developed a robust and user-friendly QR-code system. The results demonstrate the potential of digital solutions to transform traditional maintenance workflows in the maritime industry.

## 3. Results and Discussion

The implementation of a QR-Code-based system at PT. Tonasa Line's workshop marks a significant shift from traditional paper-based maintenance workflows to a modern, digitized approach. This transformation was driven by the need to address long-standing challenges, including the loss of physical documents, time-consuming data retrieval processes, and the risk of errors associated with manual record-keeping. The study aimed to evaluate the system's impact on improving operational efficiency, data accessibility, and accuracy in technical maintenance processes. Through a combination of qualitative and quantitative analysis, the results revealed how the QR-code system streamlined workflows, minimized errors, and enhanced user satisfaction. The following sections detail the system's workflow, key outcomes, and its broader implications for maritime maintenance operations.

### 3.1 Overview of Implementation

The implementation of the QR-Code-based system at PT. Tonasa Line successfully addressed several challenges inherent in technical maintenance operations. Prior to the system's deployment, maintenance relied heavily on physical documents such as nameplates, manuals, and standard operating procedures (SOPs), which were susceptible to damage, loss, and errors. By integrating QR codes with a centralized database, technicians now have instant access to accurate and up-to-date information, fundamentally transforming maintenance workflows through streamlined data retrieval and improved consistency across operations. Similar digital transformations have been reported to enhance operational efficiency in maritime and industrial settings [20, 21].

### 3.2 Workflow of the QR-Code System

The workflow of the QR-Code system simplifies access to technical data related to ship maintenance by linking QR codes on machinery or ship components to a centralized system. When scanned, users are directed to an interface allowing selection of specific ship types or machinery, as in Figure 3, providing tailored access to relevant data such as machinery specifications, operational manuals, and inventory lists. This customization is particularly advantageous for managing the diverse fleet operated by PT. Tonasa Line which encompasses various ship types with distinct maintenance requirements.


**FIGURE 3.** Ship selection menu with QR-Code

By reducing time spent searching for physical documents and ensuring data consistency, the system improves maintenance scheduling and operational readiness.

### 3.3 Results of Implementation

The results demonstrate substantial improvements in key performance indicators. Notably, the average time required for retrieving technical data was reduced dramatically, from approximately fifteen minutes to less than two minutes. This enhancement eliminated maintenance delays previously caused by misplaced or damaged documents. Furthermore, the system significantly minimized manual errors related to outdated or incomplete records, thereby increasing data accuracy. User satisfaction also improved markedly, with over ninety percent of workshop staff reporting enhanced workflow efficiency and ease of use. These outcomes align with findings from other studies highlighting the effectiveness of QR-Code technology in improving maintenance processes and user experience [14], [15][16].

### 3.4 System Features and Capabilities

The system incorporates key features that further support maintenance activities. Digital maintenance logs enable technicians to access historical records and update them immediately after task completion, fostering real-time data accuracy. The integration of QR codes with inventory management facilitates real-time tracking of spare parts availability, thus optimizing resource planning. Additionally, direct access to relevant SOPs and technical manuals via QR codes ensures that technicians follow up-to-date procedures, enhancing compliance and safety. Figure 4 shows the QR Code System Homepage.

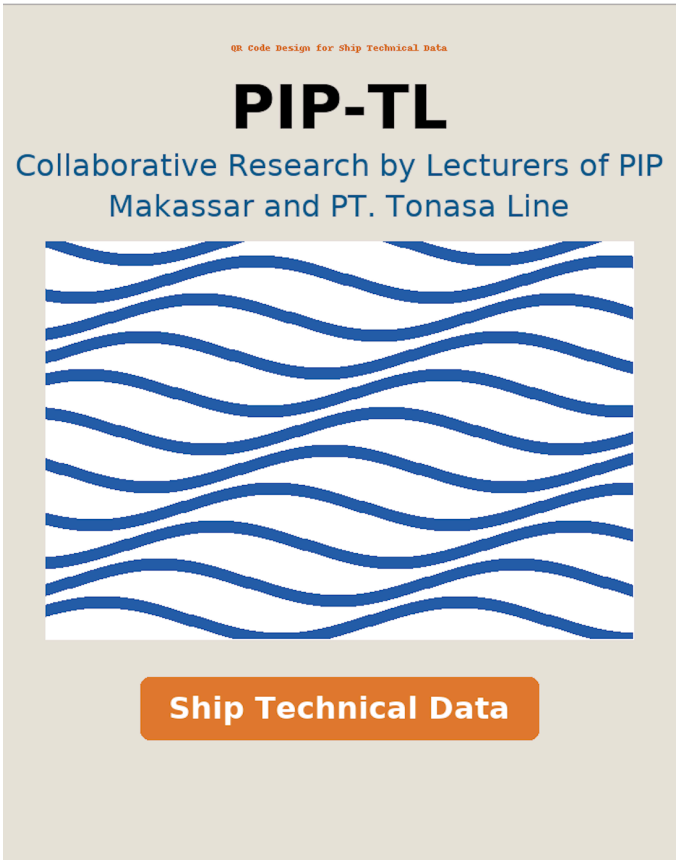


**FIGURE 4.** QR-Code system homepage

3.5 Discussion

Overall, the QR-Code system has transformed maintenance operations at PT. Tonasa Line by digitizing critical technical information and making it accessible through a centralized platform. It addresses challenges such as document loss, data inaccuracies, and inefficiencies in information retrieval that commonly hamper maritime maintenance. The system's scalability and adaptability make it a promising solution for broader applications, including inventory management and personnel training modules. Feedback from technicians emphasizes the importance of mobile accessibility and user-friendly design in improving workflow efficiency. Future enhancements may focus on integrating predictive maintenance algorithms to optimize repair schedules and further minimize downtime, aligning with current trends in smart maintenance technologies [17].

## 4. Conclusion

The implementation of a QR code-based digitization system at PT. Tonasa Line has successfully improved maintenance efficiency by significantly reducing the average data retrieval time from 15 minutes to under 2 minutes. This system also minimized errors commonly associated with traditional manual documentation by providing technicians with accurate and up-to-date technical information, thereby enhancing overall data reliability. User feedback further highlighted high satisfaction levels, especially emphasizing the system's mobile accessibility and intuitive interface design, which contributed to a smoother workflow. Moreover, the QR-code system has demonstrated considerable scalability and adaptability, showing promising potential for applications beyond maritime maintenance, including inventory management and compliance monitoring.

## Recommendation:

1. Future development should integrate predictive maintenance algorithms to further optimize repair schedules and prevent equipment failures.
2. The system minimized errors associated with traditional manual documentation by providing accurate and up-to-date technical information, enhancing data reliability for technicians.
3. User feedback indicated high satisfaction with the system, particularly due to its mobile accessibility and intuitive interface design.
4. The QR-code system demonstrated scalability and adaptability, offering potential applications beyond maritime maintenance, such as inventory management and compliance monitoring.

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## Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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