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Digitization of the Engine Room Logbook to Optimize the Planned Maintenance System (PMS) and Ship Inventory Control

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***Abstract*—** Manual recording systems in ship engine rooms often lead to data redundancy, maintenance scheduling errors, and difficulties in monitoring spare parts availability. To address these limitations, this research aims to design and develop SmartShip Log+, an integrated digital application for ship operational management, specifically focusing on digital logbook recording, the Planned Maintenance System (PMS), and spare parts inventory control. The study employs a Research and Development (R&D) methodology using the Waterfall model. Data were collected through observations, interviews, and literature reviews. The application was developed as a web-based platform integrated with a MySQL database, designed to accommodate the operational workflows of administrators, supervisors, and technicians. The results indicate that the SmartShip Log+ application successfully improves operational efficiency, facilitates real-time monitoring, minimizes recording errors, and centralizes data management. Furthermore, the seamless integration of the digital logbook, PMS, and inventory modules enables more effective maintenance planning and inventory control, thereby contributing to the digital transformation of maritime operations.

Keywords— Digital Logbook, Planned Maintenance System, Inventory Control, SmartShip Log+, Maritime Digitalization.

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I. INTRODUCTION

The rapid advancement of information technology has significantly influenced various industrial sectors, including the maritime industry. Within maritime operations, digital transformation has become pivotal to enhancing operational efficiency, streamlining maintenance management, and ensuring data accuracy. However, conventional manual logging practices persist for operational logbooks, maintenance scheduling, and spare parts inventory management. This reliance on manual systems frequently precipitates operational inefficiencies, such as data redundancy, reporting delays, document loss, human error, and substantial difficulties in the real-time monitoring of maintenance activities and spare parts availability [1] [2] [3].

A digital logbook is an electronic recording system designed to document daily operational activities onboard. Its implementation enhances data accessibility, simplifies reporting workflows, and minimizes paper-based documentation. Concurrently, the Planned Maintenance System (PMS) serves as a critical component in vessel maintenance management, ensuring that maintenance tasks are executed systematically according to predetermined schedules based on running hours and specific time intervals. Effective PMS implementation mitigates the risk of equipment failure and bolsters vessel operational reliability. Furthermore, robust spare parts inventory management is paramount to ensuring the availability of essential components during maintenance; conversely, deficient inventory control can lead to prolonged maintenance delays and escalated operational costs [4] [5] [6] [7] [8].

Prior studies have extensively explored the application of digital systems in maritime operations. However, existing research typically examines digital maintenance systems, scheduling, and inventory management in isolation. While some literature evaluates digital logbooks for tracking operational activities, most developed systems remain fragmented and lack integration into a centralized operational platform. This fragmentation reveals a distinct research gap: the separation of operational data, maintenance schedules, and inventory information compromises operational synergy and hinders real-time data synchronization.

This study is underpinned by several theoretical frameworks, including information systems integration, database management systems (DBMS), web-based application development, and maintenance management concepts. Systems integration theory elucidates how disparate operational modules can be unified into a centralized platform to optimize data efficiency and accessibility. A robust DBMS supports real-time data storage and management, while web-based frameworks

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ensure cross-device application accessibility. Additionally, maintenance management theory underscores the significance of preventive maintenance through a PMS to sustain equipment reliability and maritime operational safety [9] [10] [11] [12].

To address these identified challenges and bridge the existing research gap, this study proposes the design and construction of SmartShip Log+, an integrated digital application tailored for ship operational management. The application consolidates digital logbooks, the Planned Maintenance System (PMS), and spare parts inventory management into a centralized, web-based platform. The primary objective of this research is to design and evaluate the efficacy of SmartShip Log+ in optimizing operational efficiency, enhancing maintenance monitoring, and refining inventory control onboard. Ultimately, this study aims to advance maritime digital transformation by providing a cohesive, integrated solution for ship operational management.

II. Method

This study employs a Research and Development (R&D) methodology, utilizing a structured system development life cycle (SDLC) based on the Waterfall model. The Waterfall model was selected due to its systematic and sequential nature, which effectively supports the development of an integrated ship operational management system. The development phases comprise requirement analysis, system design, implementation, testing, and maintenance [9] [13].

The system evaluation in this study focuses on key operational parameters, including the data entry efficiency of digital logbook recording, the scheduling effectiveness of the Planned Maintenance System (PMS), and the accuracy of onboard spare parts inventory control. Rather than measuring statistical causality through experimental variables, this research assesses the functional performance, system interoperability, and deployment feasibility of the SmartShip Log+ application. These parameters are evaluated descriptively based on user workflow requirements and validated through systematic functionality testing.

Data collection was conducted through observation, interviews, documentation, and a literature review. Observations focused on ship operational activities, specifically logbook entries, maintenance scheduling, and inventory workflows. Semi-structured interviews were conducted with administrators, supervisors, and technicians to diagnose operational bottlenecks and specify system requirements. Document analysis involved reviewing historical maintenance reports, operational logs, and inventory data, while the literature review provided the theoretical foundation for maritime operational systems, maintenance management, and web-based information systems [14] [15].

A purposive sampling technique was applied to select respondents based on their direct involvement in ship operations and maintenance. The research sample comprised ship personnel who actively interact with onboard reporting and operational systems.

The system architecture was modeled following the Waterfall paradigm. The requirement analysis phase mapped the functionalities needed for the digital logbook, PMS, and inventory modules. The design phase involved database modeling, user interface (UI) design, and modular integration workflows. During the implementation phase, core features were coded and developed.

SmartShip Log+ was engineered using the PHP programming language within the Laravel framework, utilizing MySQL as the centralized database management system. The frontend user interface was constructed using HTML, CSS, JavaScript, and the Bootstrap framework to ensure a responsive, web-based deployment.

System evaluation and data analysis were conducted descriptively to assess operational effectiveness and functionality. System validation utilized the black-box testing method, focusing on core functionalities including user authentication, digital logbook inputs, maintenance scheduling, inventory monitoring, and report generation. The final output of this research is an integrated, web-based digital application designed to optimize maritime operational management and facilitate real-time maintenance monitoring.

III. Results and Discussion

A. System Architecture and Core Functionalities

The development phase successfully realized SmartShip Log+, an integrated, web-based platform that centralizes digital logbooks, the Planned Maintenance System (PMS), and maritime spare parts inventory management. By leveraging the PHP Laravel framework and a MySQL relational database, the system achieves robust real-time operational data synchronization. Adhering to the sequential phases of the Waterfall model ensured that each developmental milestone—from requirement elicitation to final deployment—was systematically validated against operational benchmarks.

B. Requirements Elicitation and Workflow Insights

Field observations and semi-structured interviews with administrators, supervisors, and technicians yielded critical insights into legacy onboard operational workflows. The data collection process successfully identified key operational bottlenecks, particularly manual data redundancy in logbook entries and latency in spare parts tracking. Consequently, these findings were translated into functional system requirements, ensuring that the developed digital platform directly addresses user constraints and optimizes daily maritime workflows.

C. System Modeling and Design Artifacts

Following the specification of system requirements, the structural and behavioral design of the application was formalized. This stage produced comprehensive Unified Modeling Language (UML) artifacts, including use case diagrams to define multi-user interactions (admin, supervisor, and technician) and class diagrams to establish object-oriented data structures. Furthermore, optimized process workflows and entity-relationship models were constructed to guarantee data integrity and seamless interoperability across the integrated modules.

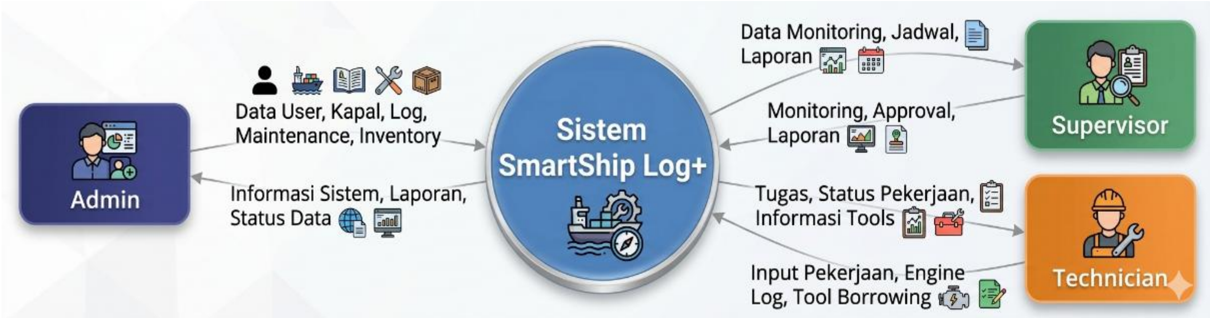

Figure. 1. Use Case Diagram SmartShip Log+ Application

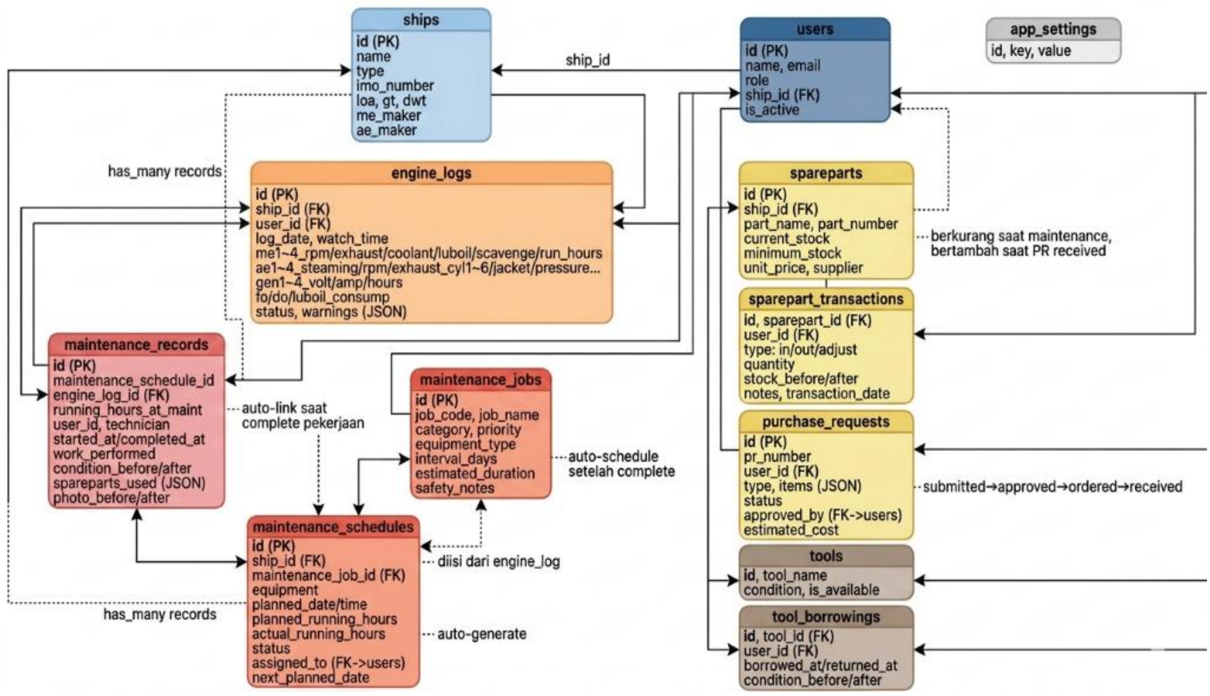

Figure. 2. Class Diagram SmartShip Log+ Application

As illustrated in Figure 1, use case diagrams map the functional interactions between distinct user personas and the system. Conversely, class diagrams delineate the static object-oriented structure, defining system entities, attributes, and their inherent logical relationships (Figure 2).

Based on this established architectural design, the developed application is operationalized through three primary functional modules: the digital logbook, the Planned Maintenance System (PMS) module, and the spare parts inventory module. These modules are structurally interconnected via a centralized database schema, enabling synchronous real-time data processing and cross-functional monitoring.

To ensure secure operational governance and data integrity, the system implements a Role-Based Access Control (RBAC) mechanism tailored to three distinct user personas:

a. Administrators are vested with full administrative privileges to manage global system configurations, user credentials, and master data.

b. Supervisors are tasked with high-level monitoring of vessel operations, maintenance analytics, and performance reporting.

c. Technicians are assigned execution-level permissions, enabling them to directly input daily operational telemetry, update maintenance logs, and record inventory changes.

D. App Login View

The user authentication interface serves as the primary security gateway to enforce Role-Based Access Control (RBAC), as illustrated in Figure 3. Rather than executing simple credential checks, the interface incorporates server-side validation algorithms to verify user identities against the relational database before granting session tokens. Engineered with responsive design patterns, this interface optimizes user experience (UX) across multi-device deployments (desktops and smartphones) while preventing unauthorized telemetry manipulation or security breaches.

The login display is also equipped with a data validation feature to ensure the security of user access to the system, with its core functionalities detailed in Table 1. If the login data entered is correct, the user will be directed to the main dashboard according to their respective roles. However, if the username or password is incorrect, the system will display an error notification so that the user can log in again.

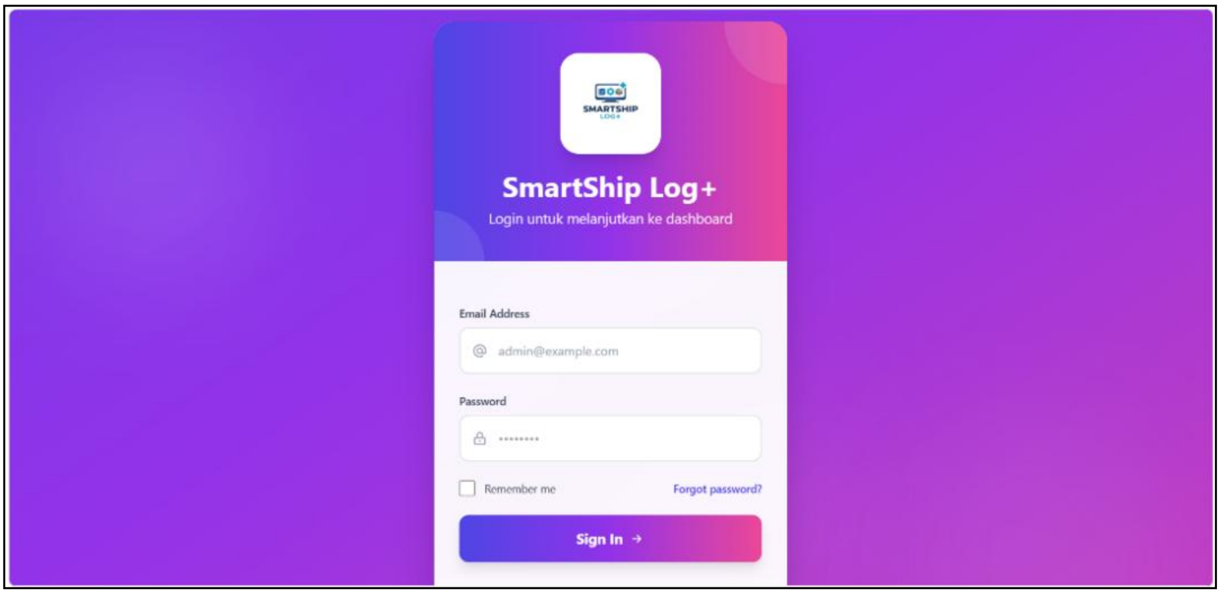

Figure. 3. App Login View

TABLE 1.
LOGIN VIEW FEATURES

No	Features	Function
1	E-mail Address	User identity input
2	Lost your password?	User authentication security
3	Login Button	System login process
4	Validation Alert	Display login error notifications
5	Role Access	Directing users to access rights

Source: Author (2026)

E. Dashboard Design and System Integration

The centralized dashboard, as shown in Figure 4, provides a multi-dimensional visualization of real-time operational telemetry, synthesizing key performance indicators (KPIs) from the logbook, PMS, and inventory modules into a single, cohesive view. The responsive user interface minimizes cognitive load for supervisors by updating maintenance alerts and stock levels dynamically. This cross-functional integration compresses the operational monitoring cycle, transforming raw system logs into actionable intelligence that empowers rapid and precise decision-making.

The integration between digital logbook, PMS, and inventory modules allows the operational monitoring process to run faster and decision-making becomes more effective. Centralized data integration also simplifies the process of generating operational reports and documentation.

F. Digital Logbook Module Design

The digital logbook module, as illustrated in Figure 5, mitigates the systemic risks inherent in manual, paper-based logging by establishing a structured data ingestion pipeline for critical engine room telemetry. This module formalizes the recording of engine running hours, mechanical parameters, and thermal conditions into standardized data formats, with its specific features detailed in Table 2. Empirical deployment demonstrates that this programmatic approach eliminates human errors in data notation, guarantees long-term data permanence, and accelerates data retrieval speeds during compliance audits.

The results of the implementation show that the digital logbook system is able to increase the speed and accuracy of data recording. Operational reports are more easily accessible because all data is stored in a centralized database. In addition, digital systems reduce the risk of document loss and minimize recording errors due to manual processes.

TABLE 2.
FEATURES OF DIGITAL LOGBOOK

No	Features	Function
1	Input Running Hours	Record machine operating hours
2	Machine parameter input	Recording the temperature and pressure parameters of the machine
3	Status Equipment	Monitoring the condition of the machine
4	Operational Record	Record daily operational activities
5	Generate Report	Create operational reports

Source: Author (2026)

The Planned Maintenance System (PMS) module operationalizes preventive maintenance scheduling through automated, event-triggered processing. As illustrated in the interface design in Figure 6, the system continuously evaluates operational running hours against predetermined machinery thresholds configured by administrators. By automating the transition from data logging to maintenance scheduling, the system generates proactive notification workflows. This algorithmic scheduling optimizes maintenance intervals, safeguards equipment reliability, and minimizes critical machinery downtime.

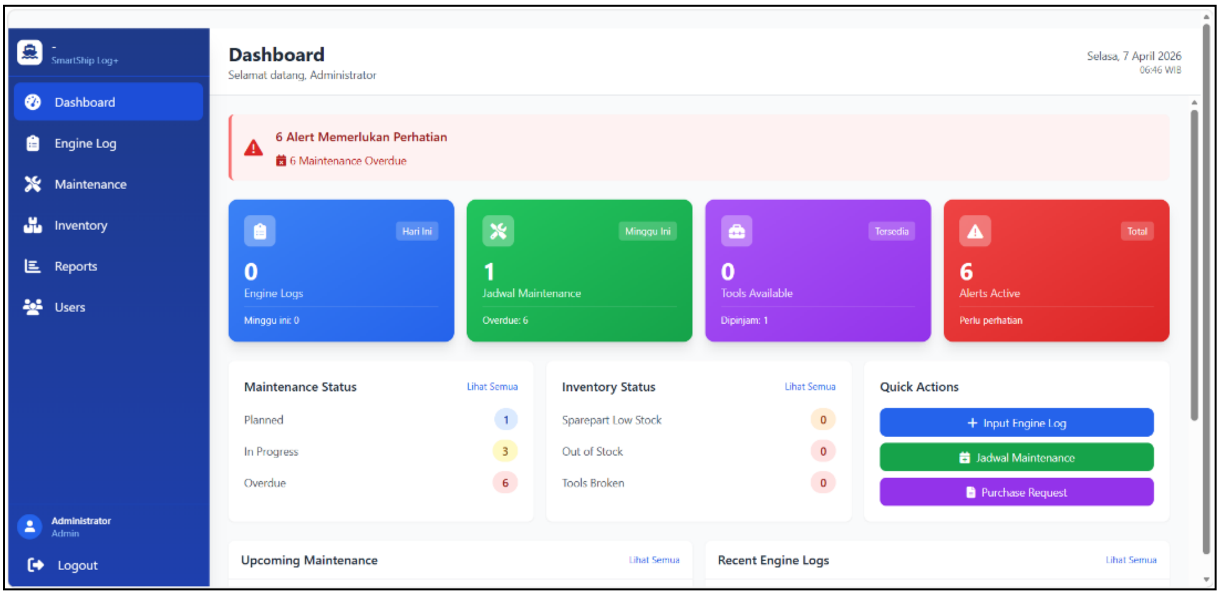

Figure. 4. Dashboard View

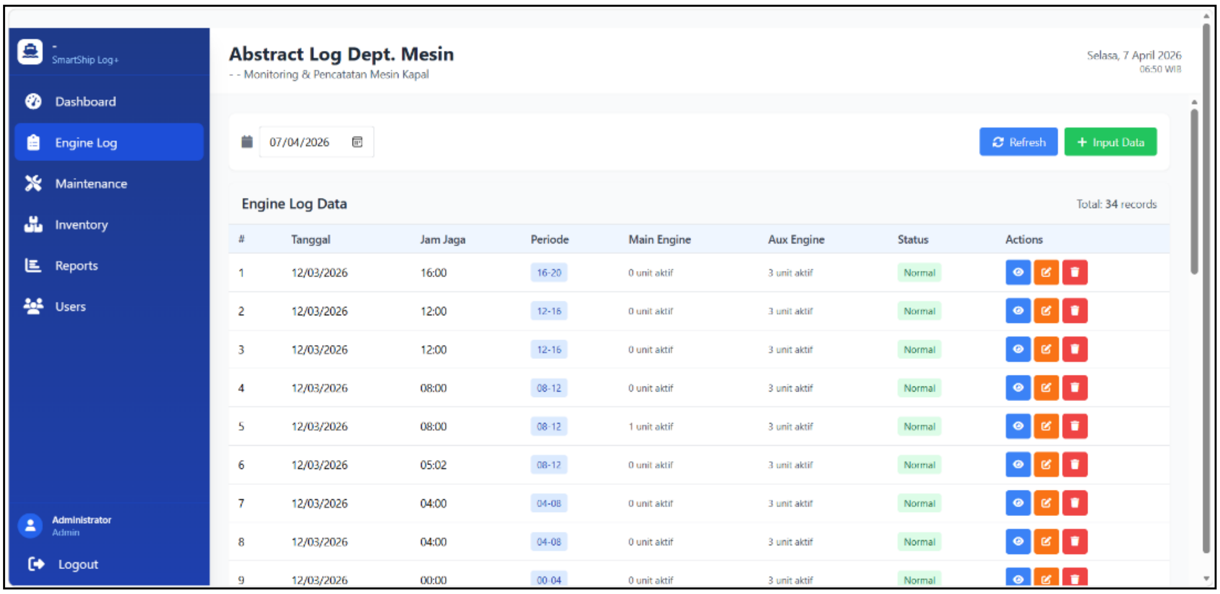

Figure. 5. Log Engine Module Design

The results of the implementation show that the PMS module has succeeded in improving maintenance monitoring and maintenance scheduling efficiency. The functional validation of these features is summarized in Table 3, confirming that all core modules operate as intended. Crucially, the system provides automated maintenance reminder notifications to significantly reduce the possibility of delays in critical maintenance activities.

TABLE 3.
THE PLANNED MAINTENANCE SYSTEM TEST RESULTS

No	PMS Functions	Results
1	Maintenance Scheduling	Successful
2	Reminder Maintenance	Successful
3	Maintenance History	Successful
4	Monitoring Equipment	Successful
5	Maintenance Reports	Successful

Source: Author (2026)

G. *Inventory Module Design*

The inventory module stabilizes the onboard spare parts supply chain through deterministic data control and asset tracking. Key features include algorithmic stock level monitoring, minimum-threshold alert pipelines, and automated consumption reporting. The visual interface and layout of this tracking pipeline are presented in Figure 7, which highlights how inventory levels and critical thresholds are displayed to users. The core analytical strength of this module lies in its tight programmatic coupling with the PMS module; the system automatically projects spare parts requirements prior to scheduled maintenance tasks, thereby eliminating supply bottlenecks and mitigating stockout risks during critical overhauls.

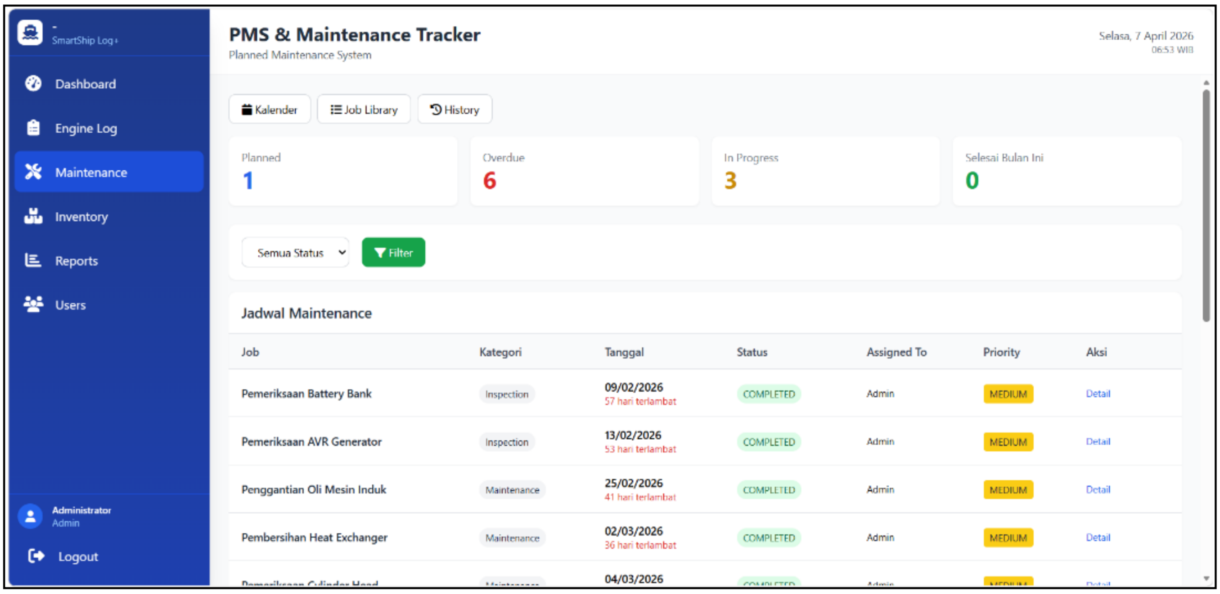

Figure. 6. Maintenance Module Design

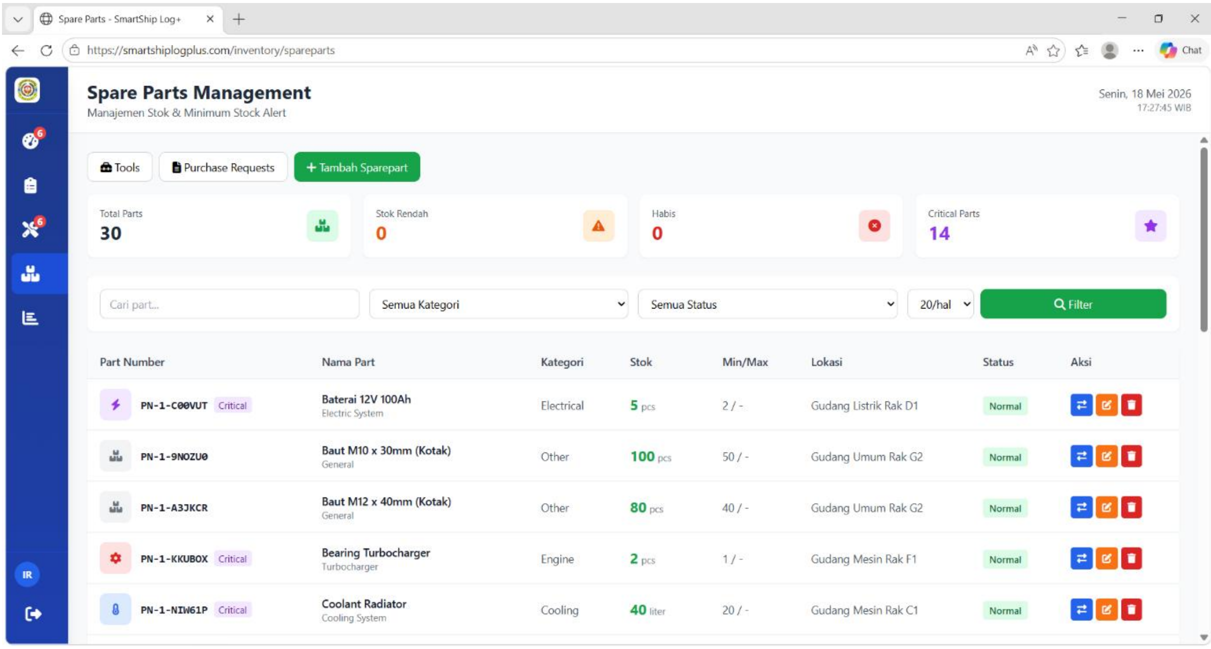

Figure. 7. Spare Part Management

The results of the study show that the inventory module is able to improve the efficiency of spare parts control and help prevent stock shortages during maintenance. The integration between the PMS module and inventory also allows spare parts needs to be identified automatically before maintenance activities are carried out.

TABLE 4.
BLACK BOX TESTING RESULTS

No	System Features	Results
1	System Login	Successful
2	Input Digital Logbook	Successful
3	Monitoring PMS	Successful
4	Inventory Spare Parts	Successful
5	Generate Report	Successful

Source: Author (2026)

System testing is done using the Black Box Testing method which focuses on testing system functions without looking at the program code directly. Testing is carried out on all major features of the application such as login, logbook input, maintenance scheduling, inventory, and generate reports. The comprehensive evaluation metrics and functionality outcomes from these test cases are summarized in Table 4.

IV. CONCLUSION

This study successfully developed and implemented SmartShip Log+, an integrated web-based platform that centralizes a digital logbook, a Planned Maintenance System (PMS), and spare parts inventory management to drive digital transformation in the maritime sector. Empirical results demonstrate that the system significantly enhances operational efficiency, mitigates data entry errors inherent in legacy manual logging, and enables real-time cross-functional data synchronization. The fundamental novelty of this research lies in its holistic framework, which harmonizes operational telemetry, preventive maintenance, and supply-chain logistics within a singular, interoperable platform, whereas prior studies typically addressed these domains in isolation. Ultimately, this platform provides a scalable blueprint for modern maritime operations, with future advancements aimed at migrating to cloud infrastructures for seamless ship-to-shore synchronization, deploying cross-platform mobile support for technicians, and integrating Internet of Things (IoT) sensors to facilitate automated predictive maintenance.

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