

Design and Development of a Web-Based Information System for the Management and Maintenance of Primary Operational Equipment (ALOPTAMA) at the North Lampung Geophysical Station

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The management and maintenance of primary equipment (ALOPTAMA) at geophysical stations play a crucial role in ensuring the reliability of earthquake observation data and other geophysical phenomena. However, maintenance recording and reporting processes at the Geophysical Station of North Lampung are still conducted using conventional and separated files, which may lead to data duplication, information inconsistency, and delays in report generation. This study aims to design and develop a web-based information system to support the integrated management and maintenance of ALOPTAMA. The system development adopts the Waterfall method, consisting of requirements analysis, system design, implementation, and testing stages. The system is developed using PHP as the programming language, MySQL as the database management system, and AdminLTE as the user interface framework. The results indicate that the developed system effectively facilitates ALOPTAMA data management, inbound and outbound inventory recording, stock monitoring, and automated, structured maintenance reporting. The implementation of the system improves operational efficiency, reduces recording errors, and accelerates the reporting process. Therefore, the proposed information system serves as a digital solution to support ALOPTAMA maintenance operations within the BMKG environment.

Keywords: Information System, ALOPTAMA, Equipment Maintenance, Web-Based System, BMKG

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1. Introduction

Digital transformation in asset management and equipment maintenance has become an essential requirement across various organizations, as manual processes are prone to persistent issues such as fragmented data, record inconsistencies, delayed reporting, and limited traceability of maintenance history [1]. The implementation of a Computerized Maintenance Management System (CMMS) or computer-based maintenance information system has been widely reported to improve maintenance discipline and asset reliability through structured data recording, scheduled maintenance activities, and faster reporting mechanisms. However, empirical studies indicate that the effectiveness of CMMS implementation strongly depends on the availability of well-organized asset data, institutional commitment, and the readiness of supporting infrastructure and network connectivity [2], [3].

In resource-constrained environments, maintenance digitalization has nevertheless demonstrated measurable positive impacts. Studies conducted in low-resource healthcare settings reveal that web-based CMMS adoption can increase the frequency of maintenance interventions, shorten corrective response times, and improve the proportion of functional assets, provided that adequate user training, local technical support, and internet accessibility are ensured [4]. These findings reinforce the perspective that maintenance information systems function not merely as administrative tools, but as strategic management instruments that enhance operational effectiveness and accountability in asset maintenance practices.

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The need for well-managed maintenance systems becomes increasingly critical in organizations operating equipment that directly influences public service quality, including geophysical and meteorological observation instruments that operate continuously. In atmospheric and geophysical monitoring practices, studies on GNSS/MET instrumentation emphasize that routine inspection, fault classification, and systematic maintenance procedures are fundamental to preserving data quality and ensuring operational continuity. This evidence highlights that equipment maintenance extends beyond a technical activity and constitutes an integral component of the data quality assurance chain that directly affects service outputs and decision-making processes.

Despite this importance, many institutions still rely on separated files and manual records, which hinder data integration across assets, maintenance history, and periodic reporting. Similar challenges have been identified in other domains, such as medical equipment maintenance, where research underscores the necessity of centralized, web-based systems to monitor maintenance and calibration activities while reducing dependence on manual documentation [5]. Based on this context, the present study addresses a research gap in the application of integrated maintenance information systems for primary equipment (ALOPTAMA) management in regional geophysical stations. This research aims to design and develop a web-based system that integrates asset data, inventory and stock movements, maintenance activities, and automated reporting within a single platform [6]. The expected contribution is a contextualized and integrated system model that enhances operational efficiency, minimizes data entry errors, and improves maintenance traceability to support the reliability of geophysical observation services [7].

2. Literature Review and Problem Statement

Asset management and maintenance constitute fundamental elements in ensuring the operational sustainability of organizations, particularly for critical assets that operate continuously and directly affect service quality. Within the context of information systems, Computerized Maintenance Management Systems (CMMS) have been widely adopted to address the limitations of manual maintenance practices by enabling integrated asset data management, preventive and corrective maintenance scheduling, maintenance history recording, and automated reporting. Wienker *et al.* emphasize that CMMS serves as a key component of *world-class maintenance* by supporting data-driven decision-making and enhancing transparency in maintenance processes, thereby reducing the risk of equipment failure caused by delayed or neglected maintenance activities [1]. Furthermore, empirical evidence indicates that the benefits of CMMS implementation are not limited to large organizations; studies in resource-constrained environments demonstrate improvements in maintenance effectiveness, faster corrective response times, and higher proportions of functional assets, highlighting CMMS as a strategic management instrument rather than merely an administrative tool [2].

In the context of specialized equipment maintenance, several studies in healthcare and technical instrumentation underline the urgency of integrated maintenance information systems. Research on web-based maintenance systems for medical equipment reports improvements in data accuracy, reductions in input errors, and enhanced traceability of maintenance and calibration histories, while also supporting periodic managerial evaluation of equipment conditions [3], [4]. These findings are highly relevant to other sectors that require high reliability and consistent maintenance documentation. In geophysical and meteorological observation systems, equipment maintenance plays a critical role in preserving data quality, as monitoring outputs are highly dependent on sensor conditions and data acquisition systems. Ma *et al.* assert that routine inspections, periodic maintenance, and systematic fault documentation for GNSS and meteorological sensors are essential components of *data quality assurance*. Irregular maintenance practices

and poor documentation can lead to data degradation, ultimately affecting the reliability of analytical outputs and early warning services [5].

Based on the literature review, a clear research gap can be identified. Existing studies predominantly focus on CMMS or web-based maintenance systems in industrial, healthcare, or laboratory settings, while the specific context of primary equipment (ALOPTAMA) management and maintenance in regional geophysical stations remains underexplored. Moreover, prior research generally emphasizes maintenance functions alone, without integrating inventory control, stock transactions, and maintenance reporting into a unified system. Consequently, this study addresses the gap by investigating how a web-based information system can integrate asset data, maintenance activities, inventory management, and reporting in a structured and effective manner at the Geophysical Station of North Lampung. The objective is to propose an applicable and contextualized maintenance information system model that enhances operational efficiency, reduces data inconsistencies, and improves maintenance traceability to support the reliability of geophysical observation services [6], [7].

Table 1. Summary of Related Research and Research Gaps

| No. | Author(s) & Year | Research Object | Approach / System | Key Findings | Limitations / Gaps |
|-----|-------------------------|--------------------------------|------------------------------|--|---|
| 1 | Wienker et al. (2016) | Industrial maintenance systems | CMMS | Improves maintenance efficiency and decision-making | Not specific to geophysical instruments |
| 2 | Beniacoub et al. (2021) | Healthcare facilities | Web-based CMMS | Increases the quantity and quality of maintenance activities | Focused on the healthcare sector |
| 3 | Fuaddi et al. (2019) | Medical equipment | Web-based maintenance system | Improves data accuracy and equipment history tracking | Does not integrate inventory and transactions |
| 4 | Ma et al. (2019) | GNSS/MET equipment | Instrumentation maintenance | Demonstrates the importance of maintenance for data quality | Does not discuss an integrated information system |
| 5 | This study | ALOPTAMA geophysical station | Web-based information system | Integrates equipment data, maintenance, inventory, and reporting | Case study limited to a single station |

3. Method

This study adopts a system development research approach with the objective of producing a functional information system that aligns with users' operational needs. This approach is commonly applied in information systems research focusing on the design, implementation, and evaluation of software solutions grounded in real-world user requirements. The system development methodology employed in this research is the Waterfall model, as system requirements were clearly identified at the early stage and the development scope remained relatively stable. This model is widely recommended for information system development in governmental and public-sector organizations with well-defined workflows [1].

System Development Stages

The Waterfall model is applied sequentially, consisting of requirements analysis, system design, implementation, and testing. To ensure a systematic and well-structured development process, each stage is completed and evaluated before proceeding to the next. This sequential approach is considered appropriate for research focusing on the design and implementation of information systems with stable and clearly defined requirements [2].

The application of the Waterfall model in this study encompasses four main stages: requirements analysis, system design, system implementation, and system testing. Each stage plays a critical role in ensuring that the developed system meets user requirements and effectively supports the integrated management and maintenance of primary equipment (ALOPTAMA) [3]. The overall development workflow adopted in this research is illustrated in Fig. 1.

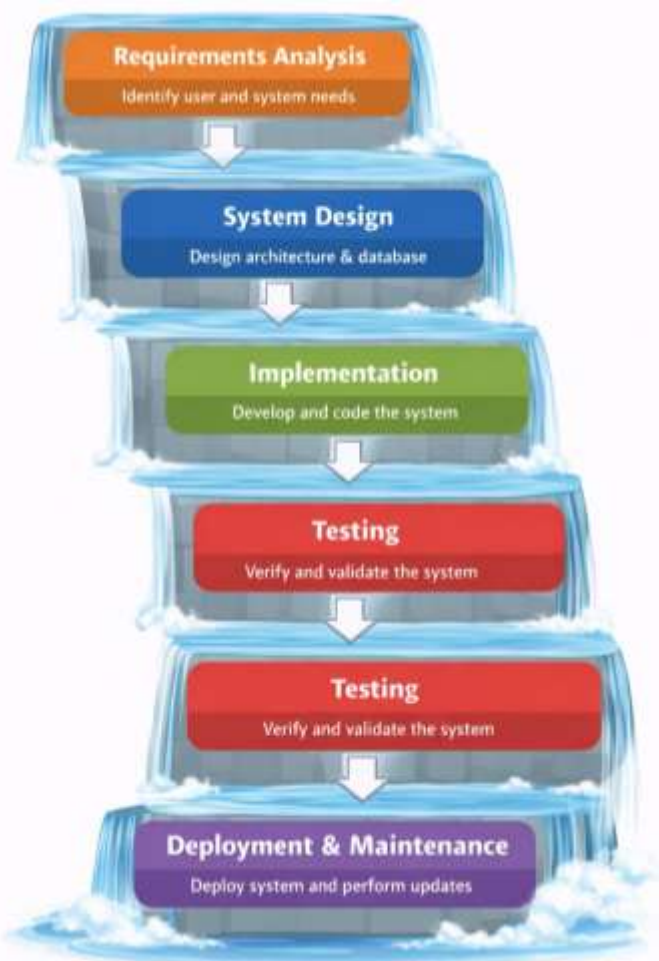


Fig. 1. Research methodology using the Waterfall development model

Each stage of the Waterfall process is conducted in a structured manner to maintain consistency and accuracy throughout system development.

1. Requirements Analysis

The requirements analysis stage was conducted through direct observation of existing asset management and maintenance processes at the Geophysical Station of North Lampung, combined with discussions with relevant operational personnel. This stage aimed to identify current workflows, types of data managed, and operational issues arising from manual and fragmented record-keeping practices. The analysis revealed the need for an integrated information system capable of managing

asset data, recording maintenance activities, controlling inventory, and generating structured and automated reports [4].

2. System Design

System design was carried out to translate user requirements into a structured system architecture. This stage involved designing system workflows, database structures, and user interfaces. The database was developed using a relational approach to ensure data consistency and integrity across multiple entities, including ALOPTAMA data, equipment categories, inbound and outbound inventory transactions, and maintenance records. User interface design emphasized simplicity, usability, and efficiency to support daily operational activities, in accordance with established usability principles for web-based information systems [5].

3. System Implementation

During the implementation stage, the system was developed as a web-based application using PHP as the server-side scripting language, MySQL as the relational database management system, and AdminLTE as the user interface framework. The selection of PHP and MySQL was based on their open-source nature, stability, and widespread adoption in institutional-scale information system development. The implemented system supports centralized ALOPTAMA data management, maintenance record documentation, inventory control, and report generation, with access regulated according to predefined user roles and permissions [3].

4. System Testing

System testing was conducted using the Black Box Testing method, which focuses on validating system functionality without considering internal code structure. Testing scenarios included validation of input, processing, and output functions, such as asset data management, inventory transactions, and report generation. This testing approach was selected due to its effectiveness in verifying that the system meets functional requirements and operates according to predefined specifications.

5. Research Object and Scope

The object of this research is the Information System for the Management and Maintenance of Primary Equipment (ALOPTAMA) implemented at the Geophysical Station of North Lampung. The system scope is limited to primary equipment data management, maintenance activities, maintenance-related inventory control, and internal reporting. The system is designed to support operational staff activities and does not include direct integration with national-scale central monitoring systems [6].

6. Analysis and Evaluation Techniques

System evaluation was conducted qualitatively based on functional testing results and the system's conformity with user requirements. System success was determined by its ability to execute all core functions without errors, generate accurate reports, and facilitate more efficient asset management and maintenance processes compared to previous manual methods. This evaluation approach aligns with information system development studies that emphasize system functionality and usability as primary indicators of effectiveness [5], [7].

4. Results and Discussion

Admin Dashboard and System Overview

As the central control component of the system, the Admin Dashboard is designed to provide a concise and comprehensive overview of operational conditions. The dashboard displays key indicators, including the number of registered stations, total equipment records, malfunctioning equipment status, preventive maintenance activities, and daily reports. Presenting information in a summarized numerical format enables administrators to monitor system conditions in real time without navigating multiple menus.

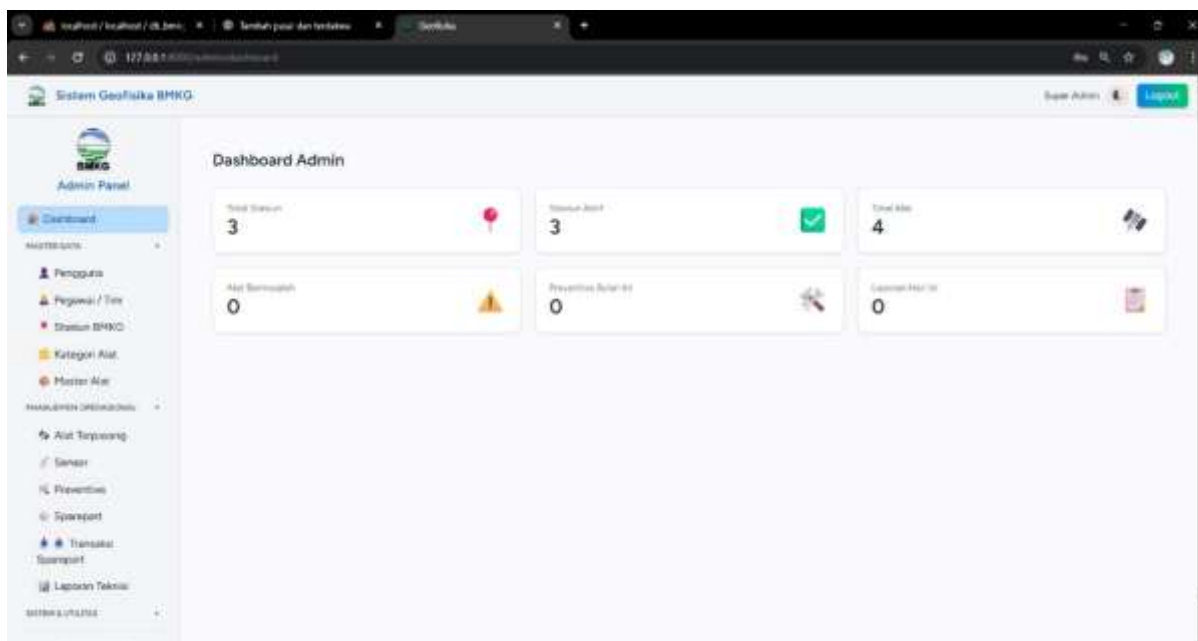


Fig. 2. Admin Dashboard of the ALOPTAMA Information System

The implementation of this dashboard aligns with the concept of an integrated maintenance information system, which emphasizes the importance of concise and data-driven information presentation to support timely and informed operational decision-making.

Master Data Management: Equipment Categories and Stations

Master data management serves as the foundation of the ALOPTAMA information system. The system provides an Equipment Category module that classifies equipment based on function and type, such as seismology instruments, accelerographs, sirens, and early warning systems. This classification facilitates structured data entry, efficient searching, and systematic maintenance analysis.

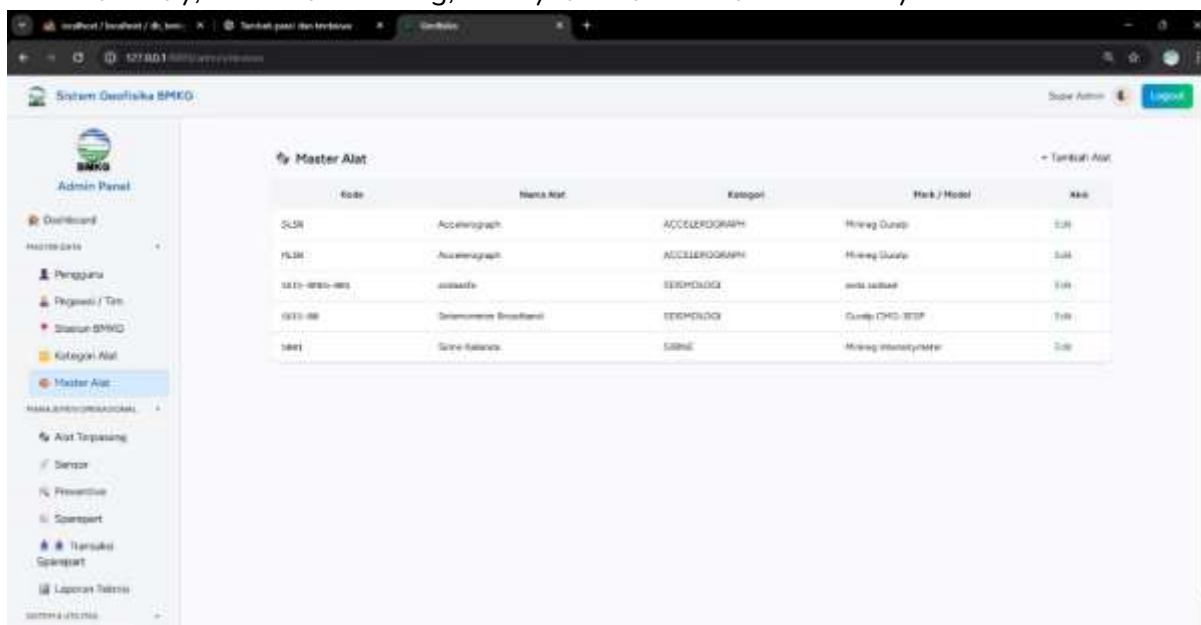


Fig. 3. Equipment Category Management Interface

In addition to equipment categorization, the system includes a Station Data module that stores station location information, geographical coordinates, and operational status. This information is essential for

associating equipment data, sensor records, and maintenance reports with specific station locations, thereby improving data contextualization and traceability.

Technician Dashboard and Operational Monitoring

To support field operations, the system provides a Technician Dashboard that functions as the primary interface for technical personnel. This dashboard presents a summary of installed devices, fault status, task lists, and sensor conditions using graphical visualizations. Such presentation assists technicians in prioritizing tasks and monitoring equipment conditions more efficiently.

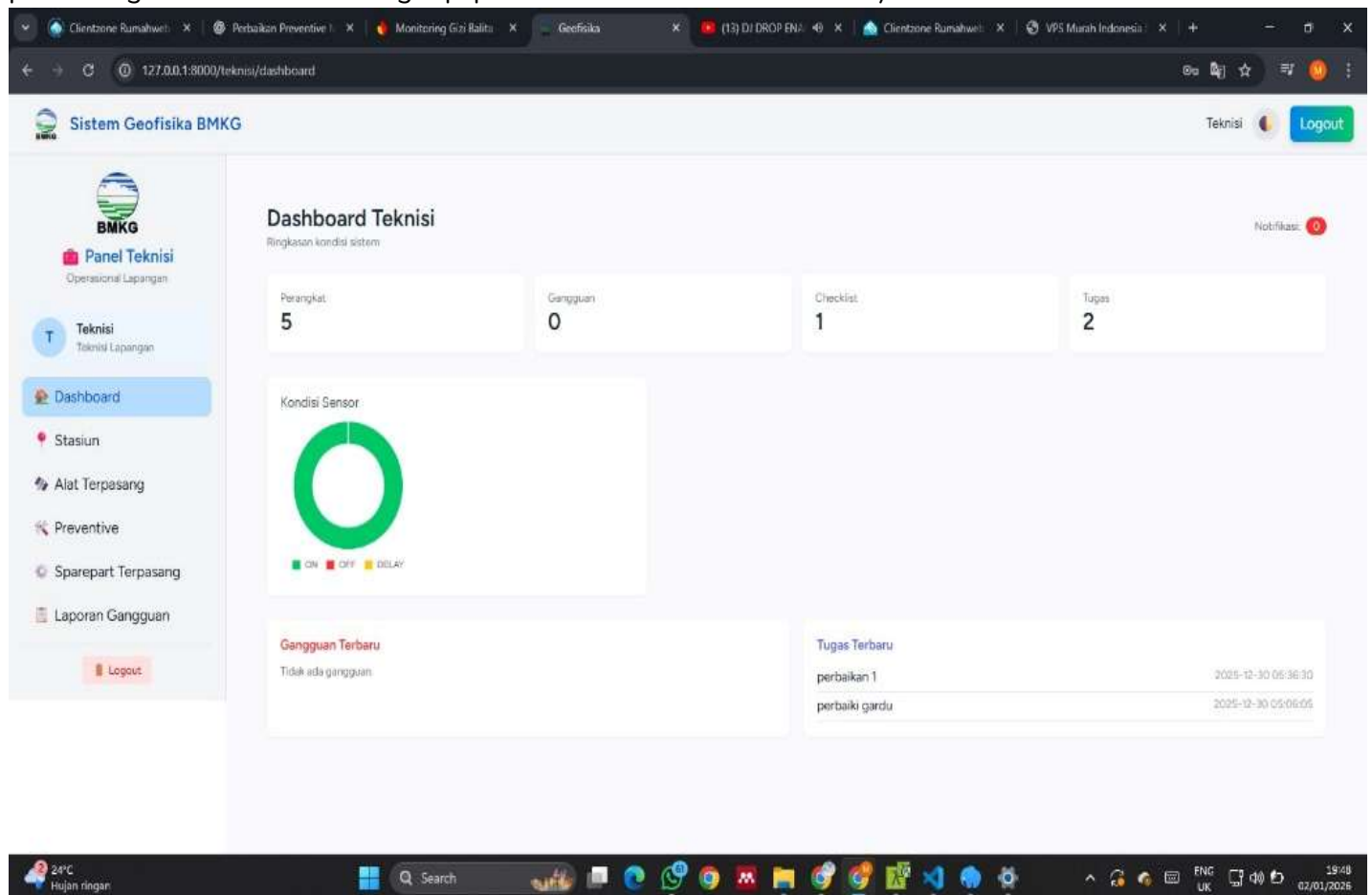


Fig. 4. Technician Dashboard and Operational Monitoring Interface

The availability of real-time visual indicators enhances situational awareness and enables faster response to potential equipment issues.

Sensor and Installed Equipment Management

The system supports detailed documentation of sensors installed at each station, including sensor type, identification code, operational status, and association with primary equipment. This module enables centralized and well-documented monitoring of sensor conditions.

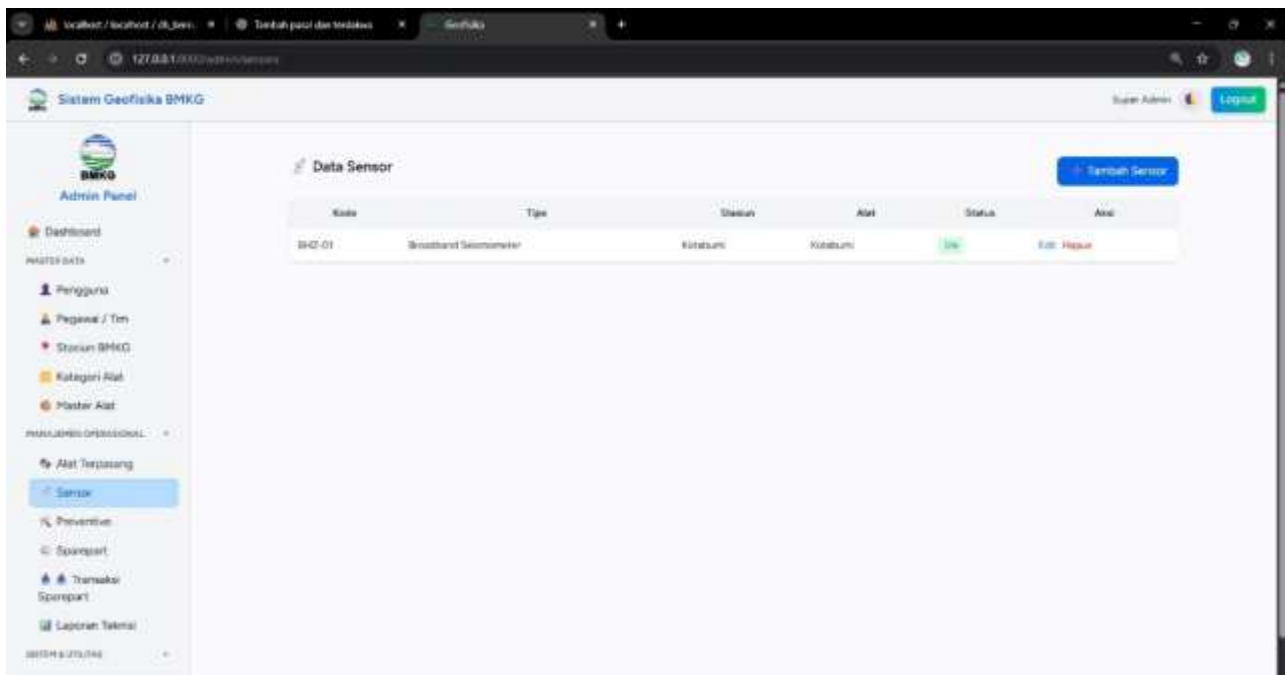


Fig. 5. Sensor Data Management Interface

Furthermore, the Installed Equipment module records equipment metadata such as category, sensor type, digitizer, equipment condition, and installation year. These records play a crucial role in tracking equipment history and supporting long-term maintenance planning.

ALOPTAMA Status Reporting and Maintenance

The system provides a status reporting feature that allows technicians to periodically report ALOPTAMA conditions. Reports include sensor status, the number of active devices, and data sources, enabling administrators to monitor equipment conditions without direct field inspections.

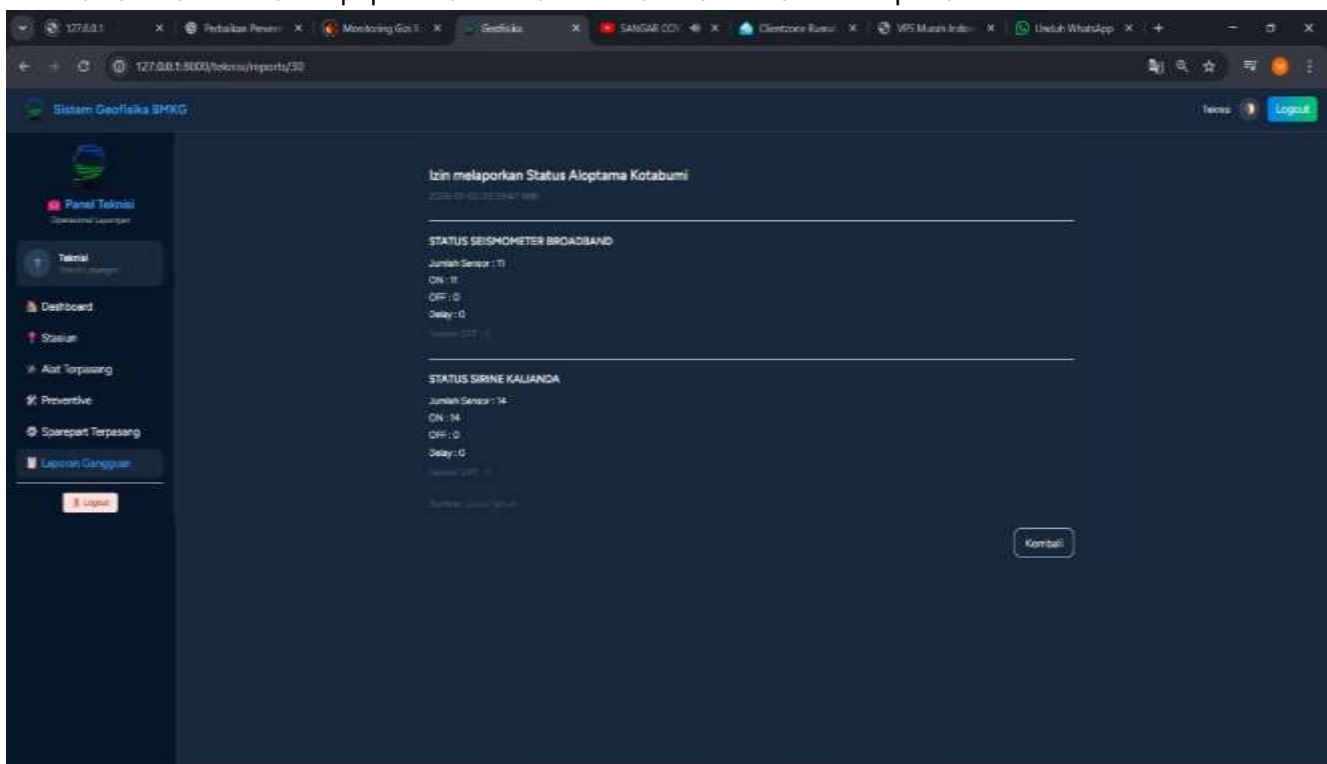


Fig. 6. ALOPTAMA Status Reporting Interface

This feature improves maintenance traceability and supports continuous documentation of equipment conditions.

Spare Parts Management

To support maintenance activities, the system incorporates a Spare Parts Management module. This module records spare part types, units, and available stock quantities. Technicians can access spare part information to ensure component availability prior to performing maintenance or corrective actions.

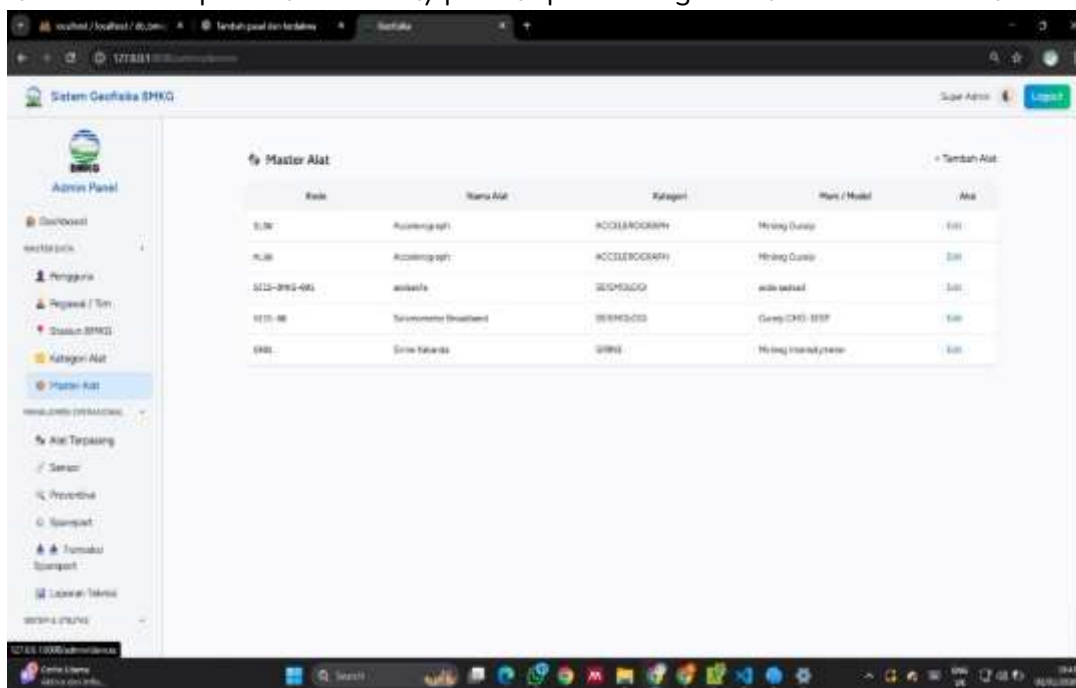


Fig. 7. Spare Parts Management Interface for Technicians

Integrating spare part data with maintenance records reduces the risk of repair delays caused by component shortages and improves inventory management efficiency.

System Testing Results

System testing was conducted to ensure that all functions of the ALOPTAMA Information System operate in accordance with user requirements and predefined specifications. The testing method employed was **Black Box Testing**, which focuses on validating the correspondence between system inputs and outputs without examining internal code structures. This method was selected due to its effectiveness in evaluating functional correctness from the end-user perspective.

Functional Testing Results

Functional testing was performed on the system’s core modules, including user authentication, master data management, maintenance transactions, spare parts management, and report generation. Each module was tested using real operational scenarios commonly executed by administrators and technicians. The summary of functional testing results is presented in Table 2.

Table 2. Functional Testing Results Using Black Box Testing

| No | Tested Module | Test Scenario | Expected Result | Actual Result | Status |
|----|---------------|-----------------------------|---------------------|---------------|--------|
| 1 | Login | Valid username and password | Dashboard displayed | As expected | Passed |

| No | Tested Module | Test Scenario | Expected Result | Actual Result | Status |
|----|------------------------|----------------------------------|-----------------------------|---------------|--------|
| 2 | Equipment Data | Add new equipment data | Data stored in database | As expected | Passed |
| 3 | Sensor | Update sensor status | Status updated | As expected | Passed |
| 4 | Preventive Maintenance | Input maintenance report | Data stored and displayed | As expected | Passed |
| 5 | Spare Parts | Update spare part stock | Stock updated automatically | As expected | Passed |
| 6 | Report | Generate equipment status report | Report displayed | As expected | Passed |

Based on the results in Table 2, all major system modules functioned correctly and produced outputs consistent with expectations. No functional errors were identified, indicating that the system satisfies essential operational requirements for ALOPTAMA management and maintenance.

Analysis of Sensor Operational Status

Beyond functional testing, the system was evaluated in terms of its ability to record and present sensor operational conditions. Sensor status data stored in the system were classified into three categories: ON, OFF, and DELAY. This analysis aimed to provide an overview of the health condition of the monitored equipment.

The distribution of sensor operational status is illustrated in Fig. 8

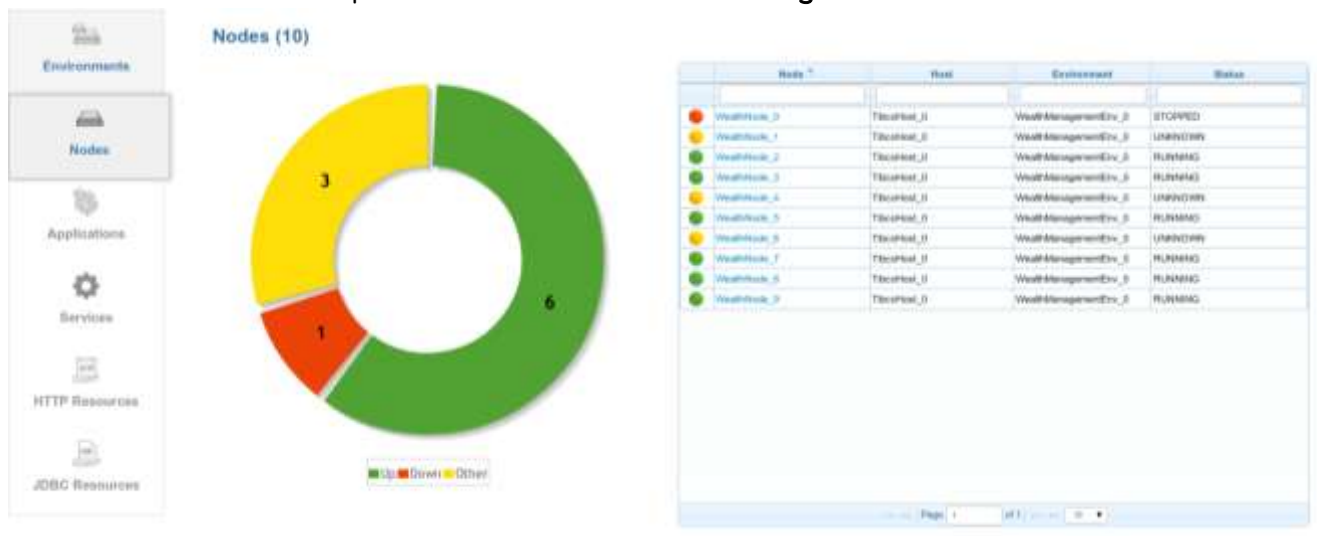


Fig. 8. Distribution of Sensor Operational Status in the ALOPTAMA System

As shown in Fig. 8, the majority of sensors were in the ON condition, indicating normal operation. The absence of sensors with OFF or DELAY status during the testing period demonstrates that the system accurately represents real-time operational conditions. This information is valuable for both technicians and administrators in supporting early detection and preventive maintenance planning.

Discussion

The functional testing results and sensor status analysis indicate that the developed information system operates in accordance with the research objectives. The successful execution of all testing scenarios confirms that module integration—from equipment data management to reporting—was achieved without

significant issues. These findings reinforce the argument that a web-based maintenance information system enhances data traceability, reduces recording errors, and accelerates reporting processes compared to manual methods.

Overall, the results demonstrate that the ALOPTAMA system is not only technically feasible but also operationally relevant in supporting asset management and maintenance activities at the Geophysical Station of North Lampung. The integration of equipment, sensor, maintenance, and spare parts data within a single web-based platform improves operational efficiency and data accuracy. These findings are consistent with previous studies on computerized maintenance systems that emphasize the importance of data integration and automated reporting. From a practical perspective, the system facilitates monitoring, reporting, and data-driven decision-making for administrators and technicians. Academically, this study contributes to maintenance information system research by presenting a contextualized case study within a regional geophysical station environment characterized by specific operational requirements.

In practice, the developed system makes it easier for administrators and technicians to monitor ALOPTAMA's condition, compile reports, and make data-driven decisions. Academically, this research enriches the study of maintenance information systems with a case study of its application at a regional geophysical station with specific operational characteristics.

5. Conclusion

This study successfully designed and implemented a web-based Information System for the Management and Maintenance of Primary Equipment (ALOPTAMA) at the Geophysical Station of North Lampung. The developed system integrates equipment data management, sensor monitoring, maintenance activities, spare parts management, and reporting within a centralized platform, thereby addressing issues related to manual record-keeping and fragmented data management practices.

Functional testing using the black box testing method demonstrated that all core system modules operated in accordance with user requirements and produced expected outputs. In addition, the analysis of sensor operational status confirmed that the system is capable of accurately representing equipment conditions and supporting real-time monitoring processes. These results indicate that the proposed system is both technically feasible and operationally effective for supporting asset management and maintenance activities.

From a practical perspective, the implementation of the system enhances operational efficiency, improves maintenance history traceability, and simplifies report generation for administrators and technicians. From an academic standpoint, this research contributes to the body of knowledge on maintenance information systems by presenting a contextualized case study within a regional geophysical station, a domain that has received limited attention in existing literature.

Nevertheless, this study has several limitations, including the deployment of the system at a single station and the absence of direct integration with a national-scale central monitoring system. Therefore, future research is recommended to focus on real-time data integration with centralized systems, the incorporation of maintenance analytics and decision-support features, and the implementation of the system across multiple geophysical stations to enhance the generalizability and scalability of the research outcomes.

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