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Design and Development of a Web-Based Radio Communication Inventory Application Using the V-Model Method

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ABSTRACT

PT Bukit Makmur Mandiri Utama is a coal mining contractor based in Binungan, Sambaliung District, Berau Regency, East Kalimantan. Especially in terms of radio communication asset inventory management, the current procedures still lack adequate structure to meet business needs. Spreadsheet applications and paper forms are still used in the manual inventory management process. This study aims to develop a web-based radio communication asset inventory information system that can assist the process of borrowing, returning, managing radio communication, and presenting radio communication asset status reports in a more structured manner. The V-Model approach is used in the development of this application which consists of the stages of needs analysis, system design, implementation, and testing. System design was carried out using Use Case Diagram, Activity Diagram and Entity Relationship Diagram modeling. The developed system has several main features, namely login, dashboard, radio communication loan, radio communication return, radio communication data management, radio communication damage, and radio communication asset status reports. Testing based on acceptance tests is carried out to test functional and non-functional aspects. The test results show that the main features of the system can run according to user needs, such as borrowing, returning, and managing radio communication data. With this system, the radio communication loan process becomes more organized, documented, and easier for companies to monitor. Further research can focus on improving notification features and developing mobile-based applications to streamline the radio communication inventory process.

Keywords: application development, web, radio communication inventory, v-model, radio communication management

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1. INTRODUCTION

Along with technological advances and changes in work methods, the need for efficiency in the business sector is increasing in today's digital era. To support their business needs, companies are now required to have efficient systems for carrying out daily operations, services, and resource management. One application is inventory management, which includes accurate recording, monitoring, and reporting. Despite this, a significant number of businesses still lack adequate technology to meet their diverse business needs [1]. This condition has the potential to reduce accuracy in asset management and hinder the decision-making process.

PT Bukit Makmur Mandiri Utama, located in the Binungan site of Sambaliung District, Berau Regency, East Kalimantan, operates a company supported by various assets, including communication radios. Currently, the process of managing the inventory of communication radio assets is still carried out manually, such as recording on paper forms and storing data in spreadsheet applications. These manual methods are prone to damage and complicate tracking of documentation [2], [3]. Furthermore, various issues arose in its operational activities, such as data duplication and record inconsistencies caused by delays in data updates. As a result, the company experienced losses due to the inability of employees to effectively monitor the status of radio communication assets and their frequent delays in submitting reports. Therefore, an application for managing radio communication asset inventory is crucial for PT Bukit Makmur Mandiri Utama's employees to carry out their work more accurately and efficiently.

Various studies have developed inventory information systems using various approaches, including the V-Model and Waterfall. In [4], an inventory system for an Islamic boarding school was developed using Waterfall. This research attempts to replace the existing manual method with a computerized system so that various information such as borrowing, returns, and reports can be documented completely and efficiently. Meanwhile, [5] discusses the development of an asset inventory system at a regional electricity company using the Waterfall

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method. The resulting inventory data management system can improve ease of inventory data management and speed up reporting. Research on system development using the V-Model has also been conducted in various studies. In [6], a web-based information management application for a student association was developed with the aim of facilitating data management, data access, and administration. Each software development approach has its own advantages, although it still depends on the characteristics of the project being developed. However, because each development stage involves interrelated testing stages, the V-Model approach is considered capable of improving software quality. This will have a significant impact on the development of systems that require structured testing and complete documentation [2], [6].

Based on the above problems, this study aims to develop a web-based radio communication asset inventory application using the V-Model method. It is hoped that the opportunity to create a web-based application for radio communication inventory will help company employees perform their jobs more efficiently by reducing errors in manual processes.

2. METHODS

This research uses the Verification and Validation (V-Model) development method. The V-Model is an application development methodology that aims to ensure that the developed system meets user needs. The development stages in this method are depicted in a vertical shape, forming a V-shape [7]. The development stages in this approach are comparable to the stages in the Waterfall method, which is an extension of that method. Instead of each stage being carried out sequentially like Waterfall, in the V-Model the stages are carried out simultaneously [8]. The V-Model method cycle can be seen in Figure 1.

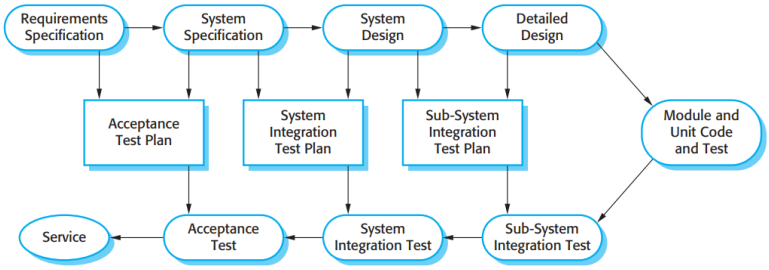


Figure 1. V-Model Cycle [7]

The stages in this research start from literature studies, observations in practical work places, interviews with users, system modeling using UML, database modeling using ERD, writing programs using PHP, to testing using blackbox testing.

2.1. System Development Method

Based on the flow in the V-Model, the stages of this research start from requirement specification, system specification, system design, detailed design, unit code, unit testing, integration testing, and acceptance testing.

2.1.1. Requirement Specification

The requirements specification stage examines the functional and non-functional requirements of the application system. Functional requirements are the primary functions the system must possess. Meanwhile, non-functional requirements are the quality standards the system must meet.

2.1.2. System Specification

The next stage, the system specification, is carried out to identify the specifications of the application system being developed, based on the previous stages. The system specification stage plays a role in providing an overview of how the application system works and meets both functional and non-functional requirements.

2.1.3. System Design

At this stage, the application suite begins to be mapped using ERDs and Unified Modeling Language (UML), such as Use Case and Activity Diagrams. This stage provides an overview of the flow and interactions between components within the system based on the requirements identified in the previous stages.

2.1.4. Detailed Design

In the detailed design stage, the application interface design begins to be developed. The interface, which is included in the client-side, is designed so that users can access web pages through their computer or device [9]. At this stage, the Graphical User Interface (GUI) display is designed based on the elements in the activity diagram.

2.1.5. Unit Code

The fifth stage is the code unit, which is the coding process for the application system being developed. The development of this radio communication inventory application was developed using the PHP programming language and MySQL database. Rasmus Lerdorf released Hypertext Preprocessor, also known as PHP, in 1995 as a programming language for creating web-based applications [10]. Meanwhile, the database used is a MySQL relational database. The relational model consists of columns with specific data types and rows with related data. E. F. Codd created this RDBMS in 1970 with the aim of simplifying data management by offering an easy-to-understand framework [11].

2.1.6. Integration Testing

After coding at the unit code stage, testing is performed on the unit code. This testing ensures that the functions in each class meet the system requirements defined in the class diagram.

2.1.7. Acceptance Testing

Finally, relevant stakeholders also conduct functional and non-functional testing on the application. This testing ensures the application meets user needs.

2.2. System Design

Functional requirements, system workflows, data structures, and relationships between application components are all described through system design. In this study, system design is illustrated using various diagrams, such as ERDs, use cases, and activity diagrams. Figure 2 below is a use case diagram to illustrate the roles between actors based on existing documents. Use cases serve to identify the functions contained within the system and who interacts with the system [12].

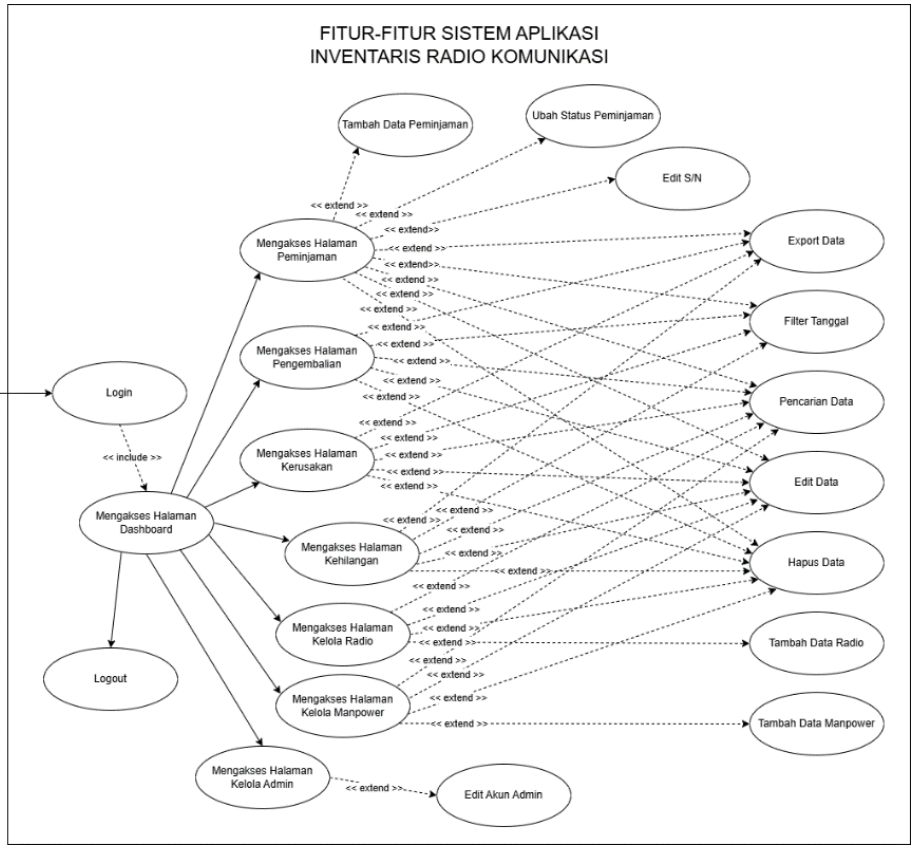


Figure 2. Application Use Case Diagram

In the developed system, the admin is the primary actor. In this design, the admin has various access rights, including access to the loan page, damage page, lost page, radio management page, and even manpower management page.

Next, to illustrate the process flow, an activity diagram was developed. With an activity diagram, the business process flow in the system can be modeled and can provide a description of system activities [12]. In this study, the activity diagram focused on the system's main processes, namely inventory borrowing, inventory returns, and radio management. The activity diagram design for the borrowing process can be seen in Figure 3.

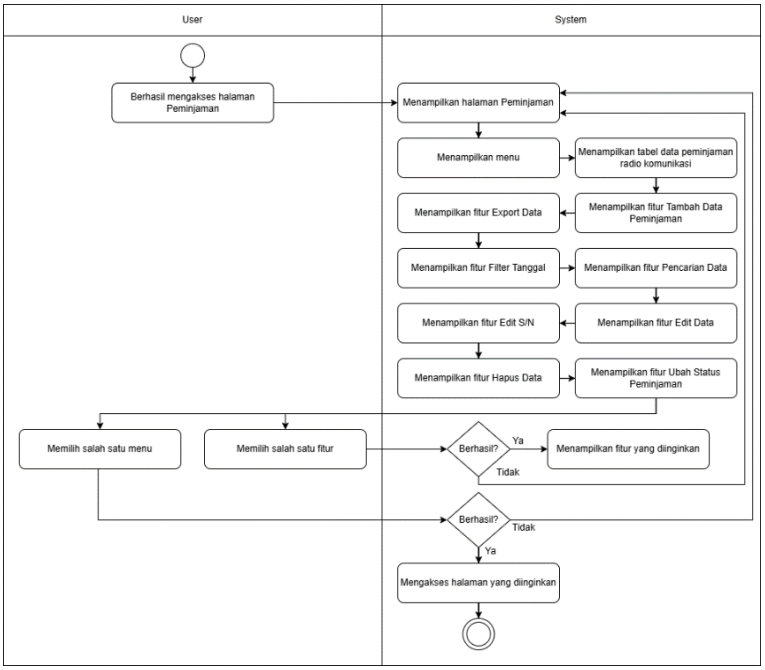


Figure 3. Loan Activity Diagram

The process begins when the user accesses the loan page, where the application displays the radio communication loan data. The user can then select one of the features available on the loan page, such as adding data, exporting data, date filtering, searching data, and changing the loan status. The user can also return the radio using the flow diagram shown in Figure 4.

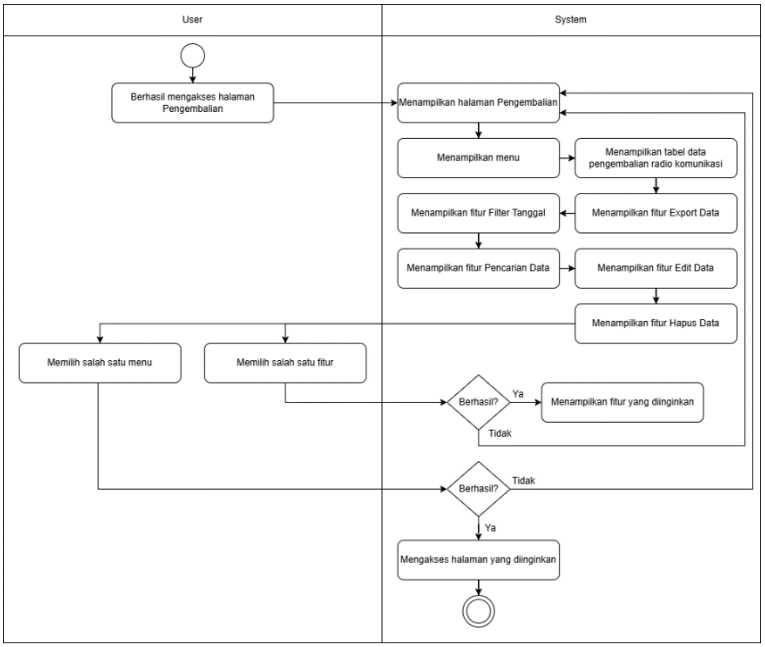


Figure 4. Return Activity Diagram

This page displays all radio communication asset return data. The return page also offers various features, such as data export, date filtering, data search, data editing, and data deletion. Another key process is radio management. The process flow for the Manage Radio section can be seen in Figure 5.

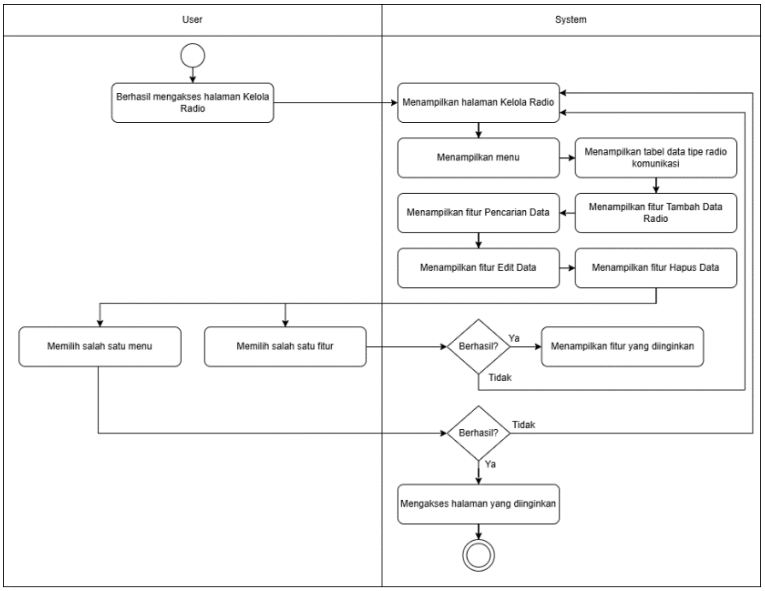


Figure 5. Radio Management Activity Diagram

The radio management section displays a table containing all data for each HT radio type. It also offers several features, including adding radio data, searching for data, editing data, and deleting data.

The next design diagram, namely the ERD, is used to explain the database structure in the asset inventory application. The ERD illustrates the relationships between entities needed to enable the application's data management and storage procedures. In this study, the ERD was developed based on the Chen version of the notation introduced in 1976 [13]. The ERD design is built based on information obtained from user requirements specifications, namely what is needed to manage and process data [14]. The results of the application's ERD design are shown in Figure 6.

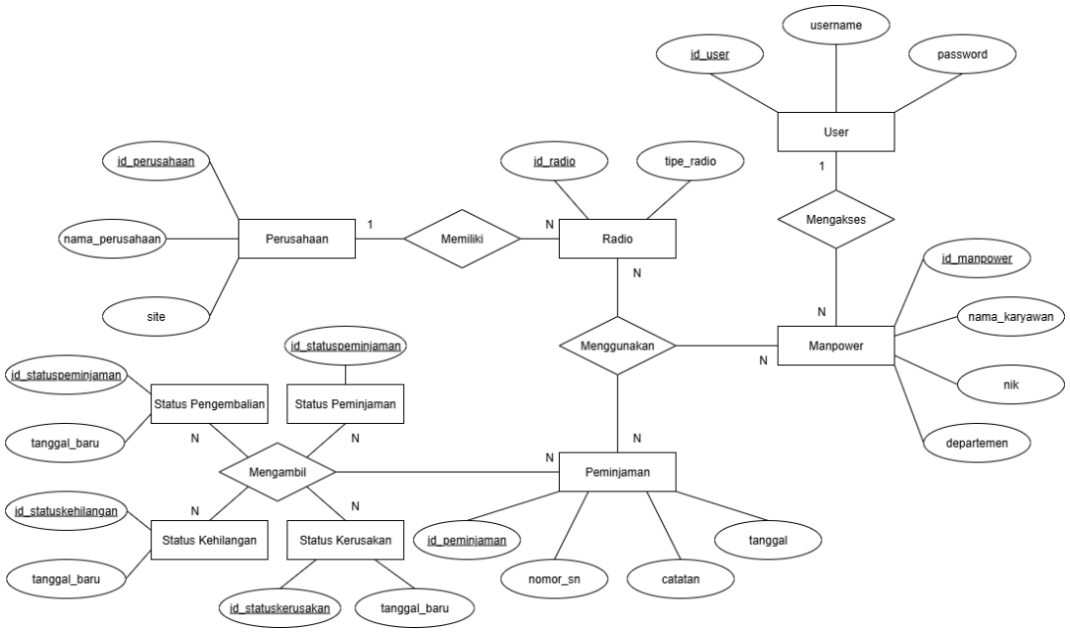


Figure 6. Application ERD

The ERD identifies several entities: the company, the radio, the workforce, the loan status, the return status, the lost status, and, of course, the user. Based on Figure 6, each user can contact the workforce, who can then borrow radio communication assets according to their work needs. The loan process will display information about the person (the workforce) borrowing the radio communication asset, the asset being borrowed, and the loan date.

3. RESULTS AND DISCUSSION

The result of this research is a web-based application for managing radio communication asset inventory, which is used to assist in the process of borrowing, returning, and monitoring asset usage. The application development is guided by the V-Model stages described in the research methods section.

The application development process begins with the verification phase, which includes requirements specification, system specification, system design, and detailed design. This is followed by a validation (trial) process, which includes subsystem integration tests, system integration tests, and acceptance tests.

3.1. System Implementation Results

This application's main features include user login, asset lending, asset return, and asset damage reporting. Additionally, it offers loss monitoring, radio management, manpower management, admin management, and data export. Each feature is tailored to user needs, as investigated during the requirements specification phase. Table 1 below lists the application's features.

Table 1. List of Features

No	Features	Description
1	Login	Used as an entry point to the system as well as access rights restrictions.
2	Dashboard	Displays inventory data summary
3	Loans	Used to apply for asset loans
4	Returns	Used to apply for asset return
5	Damage	Used to manage asset damage information
6	Loss	Used to manage asset loss information
7	Manage Radio	Used to manage radio asset stock
8	Manage Manpower	Used to submit management related to manpower
9	Manage Admin	Used for application access data management
10	Export Data	Used to generate data in PDF, Excel, and print formats.

On the login page, users will be asked to enter the username and password registered in the system. The login page serves as the initial interface displayed to the user. The application login page is shown in Figure 7.

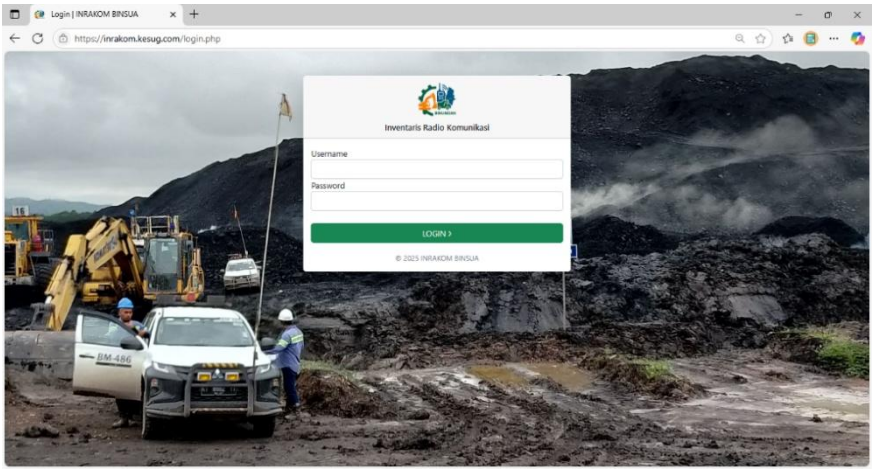


Figure 7. Login Page Display

After logging in, the system will display a dashboard page that provides a summary of inventory asset information, such as total radio loans, total radio returns, total radio damage, and total radio losses. Figure 8 shows a view of the dashboard page.

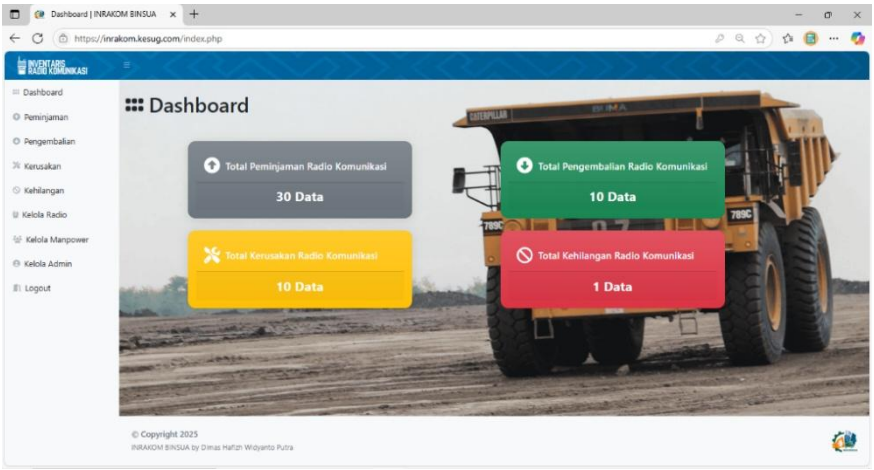


Figure 8. Dashboard Page View

One of the system's main features is the radio loan application. Users can select the type of HT radio, specify the loan date, and fill in the loan notes. They can also change the loan data to one of the status categories. The radio loan page can be seen in Figure 9.

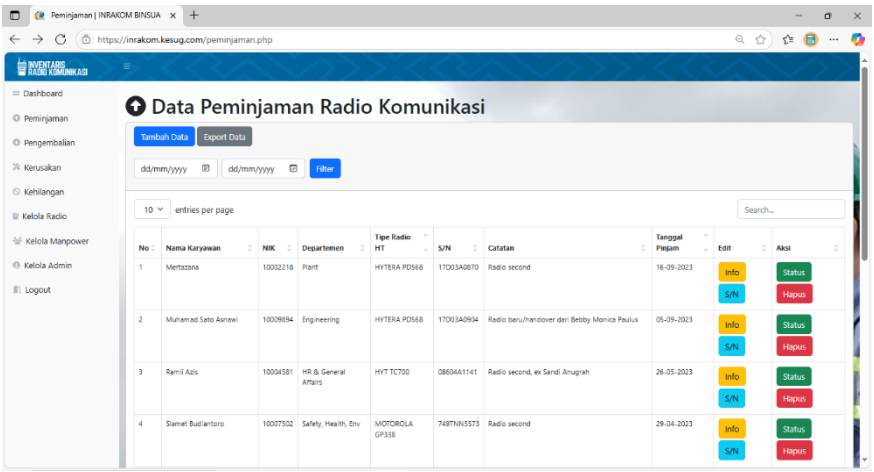


Figure 9. Loan Page View

In addition to borrowing, users can also return radio communications equipment on the returns page. Here, users can update and even delete returned radio communications data. Figure 10 displays the returns page interface.

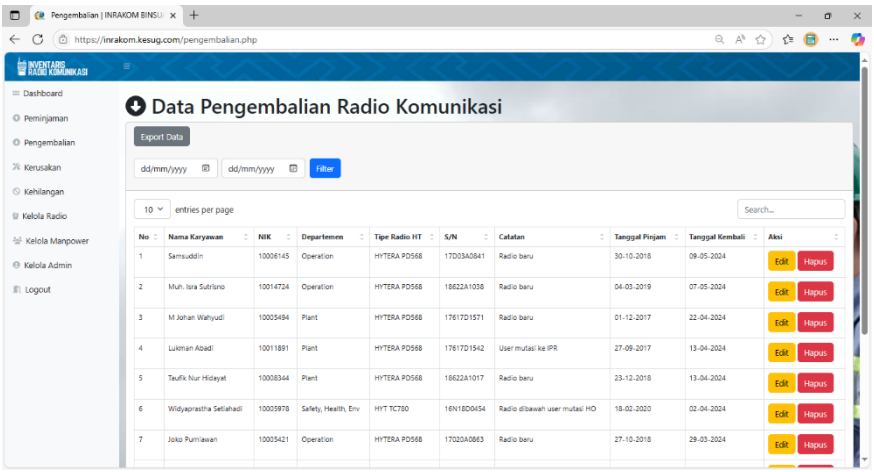


Figure 10. Return Page View

Another feature allows users to enter and delete HT radio type data. This simplifies the process of managing communication radio type information. The radio management page can be seen in Figure 11.

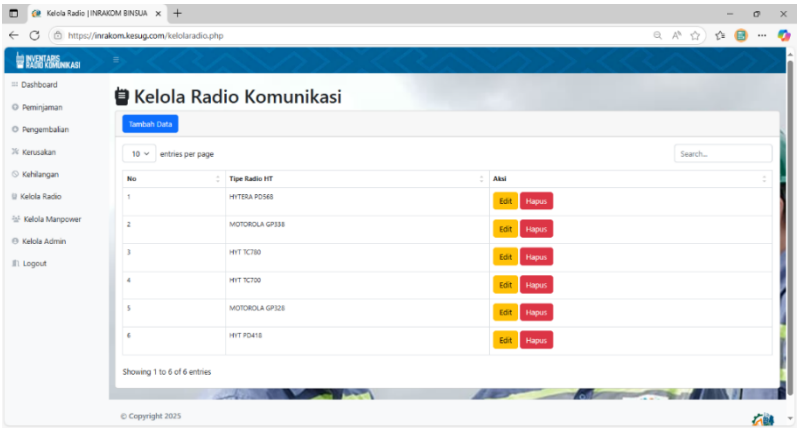


Figure 11. Radio Management Page View

3.2. System Test Results

In order for the developed system to run well and meet user needs, system testing is necessary. Testing is carried out to find application inconsistencies before user use [15]. The first test is the acceptance test, where testing is carried out to assess whether the features and quality of the system are in accordance with the specified needs. In this section, two types of testing will be carried out, namely functional testing and non-functional testing. To ensure that each main feature of the application can operate as it should, functional testing is carried out. The results of the functional testing can be seen in Table 2.

Table 2. Functional Part Acceptance Test Results

No.	Test Description	System Features	User Requirements Results
1	User authentication testing	Login	Very Suitable
2	Initial display suitability testing	Dashboard	Enough
3	Ensure the appearance of the loan data management page is appropriate	Loan Page	Very Suitable
4	Ensure the appearance of the return data management page is appropriate	Return Page	Very Suitable
5	Ensure the conformity of the radio data management page display	Manage Radio Page	Very Suitable

Based on Table 2, it can be seen that several features in the application can function according to user needs. This finding indicates that the system has met functional criteria, particularly related to inventory data maintenance, damage tracking, loss recording, borrowing, and returns. Non-functional testing was then conducted to evaluate aspects of the system quality beyond its core functions, such as response time, processing time, reliability, availability, consistency, and simplicity. Table 3 below shows the results of the non-functional testing.

Table 3. Non-Functional Part Acceptance Test Results

No.	Testing	Questions	Answers
1	Response time	Can the system respond to requests in less than 3 seconds?	Enough
2	Processing time	Can the system complete the data management process in less than 5 seconds?	Enough
3	Reliability	Is the information displayed or processed by the system accurate and easy to understand?	Easy
4	Availability	Do you always have easy access to online systems?	Easy
5	Consistency	Are the background images on each page presented consistently and easily understood?	Enough
6	Simplicity	Do the system features make it easy for you to find the information you need?	Enough
7	Safety	Does the system readily reject your login attempts if your username and password are invalid?	Very Easy

Table 3 shows that the system meets the tested non-functional requirements. Based on the assessment results, the system is easy to use, responds quickly to user commands, displays accurate and easy-to-understand information, and provides user authentication for access restrictions.

In addition, to ensure that the application features meet user needs, testing is conducted at the requirements specification, system specification, system design, and detailed design stages. Evaluation at the requirements

specification stage, the results of the identification of functional and non-functional requirements are obtained through observation activities and interviews with interested parties. At the system specification stage, the evaluation of the system specifications is obtained based on the functional and non-functional requirements that have been previously identified. Furthermore, at the system design stage, the evaluation is generated based on the needs that have been identified in the previous stage. Then, the evaluation at the detailed design stage is generated based on the previously determined system design. The result of this design is an interface display that describes the appearance of the application pages. The results of the validation process can be seen in Table 4.

Table 4. Validation Results

Verification Stages	Validation Process
Requirement Specification	The results show that users agree with the functional and non-functional requirements that have been set
System Specification	The results show that users agree with the system specification requirements that have been set
System Design	The results show that users agree with the system design that has been established
Detailed Design	The results show that users approve of the established interface design

Based on the validation results, all verification stages have received user approval. This finding indicates that user expectations were met throughout the system design process, from the requirements specification stage to the detailed design stage.

Furthermore, an evaluation is also carried out at the unit code stage. Determining the project structure and developing programs in the front-end and back-end are two steps taken to implement the system design during the unit code stage. The user interface (UI) display part of a web application that communicates directly with the user is known as the front-end. This part also contributes to the user experience (UX) when the user interacts with the web interface in both directions [16]. Meanwhile, the back end refers to the server-side part of a system or application that manages and modifies database data [17]. The validation results at the unit code stage can be seen in Table 5.

Tabel 5. Hasil Validasi *Unit Code*

Unit Code Stages	Validation Process	Review
Project Structure	The client-side and server-side structures are defined in line with the system design	User Agrees
Front-End	The components that have been implemented are aligned with the user interface design.	User Agrees
Back-End	The functions that have been implemented are in line with the system design.	User Agrees

Based on the validation results, the user has approved the unit code stage, which aligns with the system design. This result indicates that user needs have been met through implementation from the project structure stage to the back-end.

3.3. DISCUSSION

The system's ability to streamline the radio communications inventory process is demonstrated by the implementation results above. Prior to the system, the loan process was typically conducted manually using spreadsheets, potentially leading to errors by employees and delays in updating asset information. With this radio communications asset inventory application, every loan application can be digitally recorded and managed in a more structured manner by the administrator.

Because each development stage is connected to a testing stage, the V-Model approach simplifies the system development process [7], [8]. This is also in line with the principles of the Software Development Life Cycle (SDLC), a process carried out in developing application systems, which consists of the planning, analysis, design, implementation, testing, and maintenance stages [18]. The basis for designing features, implementation, and testing comes from user needs that have been identified and formulated previously.

Furthermore, based on the test results, various tested features were well received. This indicates that the developed system is in accordance with the design and user needs. The login feature is considered capable of increasing security by limiting user access, the radio communication loan application feature can store data well, the return feature can be used easily, and the interface display maximizes the user experience. Essentially, testing measures how the application is perceived by end users [19], [20].

However, this application still has limitations. The system doesn't yet offer automatic user notifications. Furthermore, a mobile version of the application is not yet available. Further development could focus on adding notification features and a mobile version.

4. CONCLUSION

This research successfully designed and implemented a web-based radio communications asset inventory application. This system eliminates the manual spreadsheet recording process previously employed. Furthermore, radio communications asset management can be performed more efficiently through features like asset management, asset damage, asset loss, and digital report export in PDF format.

The implementation of the V-Model approach has proven effective in ensuring the system meets user needs, as it allows development to be carried out in stages from verification to validation, by integrating testing and documentation processes at each stage. This study contributes to the literature on asset management information systems by combining the application of the PHP programming language and the V-Model method, and provides empirical evidence that this approach can produce a system that meets user needs.

Further development could focus on integrating notification features, allowing users to receive real-time information regarding borrowing, returning, delays, damage, and loss of radio communications assets. Furthermore, development could also be carried out on a mobile app version to allow for more flexible radio communications inventory management.

DATA AVAILABILITY STATEMENT

Data related to this research are available from the corresponding author upon reasonable request, subject to existing research ethics and data protection requirements.

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In compiling this research, the author used ChatGPT to assist with language editing, application interface creation, and application code development. All AI results have been verified and adjusted by the author.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest regarding the publication of this research.

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