Journal of Applied Informatics and Computing (JAIC)
Vol.x, No.x, Juli 201x, pp. xx~xx
e-ISSN: 2548-6861

Analysis of Resource Information System Efficiency for Manpower Management in the In Circuit Testing (ICT) Workstation

Fitriani [1]*, Noper Ardi [2]*
* Informatics Engineering, Batam State Polytechnic
** Software Engineering Technology, Batam State Polytechnic
fitriiannyy@gmail.com [1], noperardi@polibatam.ac.id [2]

Article Info

Article history:

Received …
Revised …
Accepted …

Keyword:

Digitalization, Time Efficiency, Value Stream Mapping, Capacity Planning, In-Circuit Testing.

ABSTRACT

The management of manpower allocation (headcount) and tester equipment within the In-Circuit Testing (ICT) workstation at PT. XYZ relies on a manual, Microsoft Excel-based approach. The absence of a centralized database causes data redundancy, human error risks, and operational inefficiencies due to cross-departmental email coordination. This study aims to develop a web-based resource information system to digitalize allocation calculations and quantitatively evaluate workflow efficiency improvements. Software development was executed using the Rapid Application Development (RAD) methodology with ASP.NET MVC and SQL Server, while information flow performance was evaluated using Value Stream Mapping (VSM) under a comparative descriptive quantitative approach. System reliability claims were validated through a time-series dataset collected over an 8-week observation period. The developed system successfully automated key functions, including BOM Explosion, Man-Hours Analysis, capacity planning, and interactive dashboard visual analytics. Empirical evaluation demonstrates that system implementation significantly enhances operational efficiency, reducing the Process Lead Time by 93.49% (from 146.00 minutes to 9.50 minutes), eliminating coordination Waiting Time completely (from 22.00 minutes to 0.00 minutes), and increasing the Value-Added Ratio (VAR) from 10.27% to 74.42%. Overall, this digital transformation enables agile, targeted, and accurate resource allocation decision-making.

I. INTRODUCTION

Efficient resource management is a crucial element in maintaining competitiveness within the modern manufacturing industry, particularly in the electronics assembly sector such as Printed Circuit Board Assembly (PCBA). Driven by the increasing complexity of electronic device designs and market demands for high quality alongside shorter lead times, manufacturing enterprises are required to optimize every stage of their production processes [1]. One critical stage in the PCBA production chain is the In-Circuit Testing (ICT) process, which evaluates electrical integrity, connectivity, and component parameters on printed circuit boards. Although Functional Circuit Testing (FCT) is also conducted in certain areas as a supporting measure, the ICT area remains the primary workstation that decisively dictates final product quality. Managing resource allocation including headcount and the number of test equipment units at the ICT workstation serves as a vital factor influencing overall production efficiency.

However, in practice at PT. XYZ, resource management at the ICT workstation is still operated manually using Microsoft Excel. The existing workflow involves unintegrated, cross-departmental coordination. The process begins when the Industrial Engineering (IE) team must request and update Build Plan data from the Planner team via email. Separately, the IE team must also request Demand data from the Program Administrator (PA) team. Upon receiving all Excel files, the IE team manually opens multiple spreadsheets and consolidates the data into a single master file for calculation using functions such as copy-paste and VLOOKUP. This procedure is time-consuming and heavily

e-ISSN: 2548-6861

reliant on user meticulousness. Consequently, any data input error or update delay directly impacts the accuracy of workforce planning and tester utilization. This manual Excel-based approach exhibits several systemic limitations in supporting enterprise-level collaboration. Asynchronous data exchange across departments via email triggers data redundancy and document version inconsistencies. Furthermore, the absence of a centralized database and concurrency management prevents simultaneous file access or updates. This indicates that operational time inefficiencies and cross-departmental collaboration hurdles are not merely caused by a lack of human capability (human error) in executing spreadsheet formulas. Rather, they stem from the standalone software architecture's inability to facilitate centralized data integration and historical analysis [2]. This condition ultimately leads to sub-optimal projections of tester and headcount allocations. In a dynamic manufacturing environment where demand and production capacity fluctuate rapidly, delayed or inaccurate resource allocation can induce productivity declines and increased waiting times [3]. To address these issues systematically, an approach is required that not only digitalizes the workflow but also quantitatively measures the resulting efficiency gains. Therefore, this study digitalizes the resource management system through the development of a web-based information system. The system is designed to replace manual Excel workflows with an automated process capable of rapidly, accurately, and efficiently calculating workforce requirements and tester allocations. Additionally, it enables users to upload data, display calculation results, and generate informative dashboards.

This digitalization initiative aligns with the strategic direction of digital transformation in manufacturing toward the Smart Factory concept, which emphasizes automation and data-driven decision-making [1]. Implemented via a web-based information system, the resource management process is expected to become more effective, efficient, and adaptive to changing production conditions. Beyond digitalization, this study highlights the importance of efficiency analysis using the Value Stream Mapping (VSM) method. VSM is highly imperative in this context as it visually maps the end-to-end workflow, identifies value-added and non-value-added activities, and highlights time and resource waste. Through the VSM approach, researchers can compare conditions before and after system implementation from the current state to the future state thereby providing measurable proof of efficiency improvements.

Based on this background, the research questions of this study are formulated as follows:

1. How to develop a web-based resource information system capable of digitalizing workforce and tester management processes at the In-Circuit Testing (ICT) workstation?
2. What is the execution time efficiency level of the resource management process following the implementation of the web-based information system compared to the manual method, based on a Value Stream Mapping (VSM) evaluation?

Accordingly, the primary objectives of this study are to construct a web-based resource information system and to analyze as well as quantify the processing time efficiency gains between the manual method and the web-based system using a VSM approach. The scope of this study focuses on headcount and tester allocations at the ICT workstation of PT. XYZ, with work efficiency evaluations grounded in operational time-series data collected over an 8-week observation period.

II. METHOD

A. Review of Related Research

Several prior studies have investigated operational efficiency improvements through the implementation of information systems and Lean Manufacturing principles. A study by Abimanyu et al. [4] analyzed the efficiency of a web-based employee attendance tracking system using the Wilcoxon Signed Rank test, demonstrating that the web-based system was significantly faster than the manual method. Isprasetia et al. [5] examined waiting time efficiency in hospital services through the implementation of a Hospital Information System (SIMRS). Pratama et al. [6] implemented a Laravel-MySQL framework for raw material management, recording a 58.88% increase in processing time efficiency. In the context of workflow waste identification, Patil et al. [7] and Noviyana et al. [8] utilized Value Stream Mapping (VSM) to identify non-value-added activities and reduce manufacturing lead times. Table I summarizes the positioning of this study relative to prior research.

Table 1. Comparison with Previous Research

Author	Title / Topic	Method / Technology	Limitations / Research Gap
Abimanyu et al. (2025) [4]	Comparative Study of Manual vs. Web-Based Attendance	Quantitative Experiment, Wilcoxon Signed-Rank Test	Limited to administrative attendance; does not address manufacturing resource allocation.
Isprasetia et al. (2025) [5]	Impact of Hospital Information System (SIMRS) on Waiting Times	Quantitative, SIMRS Service Evaluation	Contextualized in the healthcare sector; does not address manufacturing line allocation.
Patil et al. (2021) [7]	VSM to Enhance Productivity	Value Stream	Did not integrate a centralized

	in Manufacturing	Mapping (VSM)	digital information system.
Pratama et al. (2025) [6]	Raw Material Management Information System	Waterfall, Laravel, MySQL, UAT	Did not focus on headcount and tester utilization calculations, nor VSM analysis.
Noviyana et al. (2024) [8]	Lean Manufacturing using VSM at PT. XYZ	VSM Current vs. Future State	Broad focus on general factory workflows rather than specific automation of the ICT workstation.
This Study (2026)	Resource Information System for ICT Workstation	RAD, ASP.NET MVC, SQL Server, VSM, Black-Box Testing	Addresses the research gap by integrating VSM evaluation with a centralized resource information system for testing workstations.

B. Research Flow

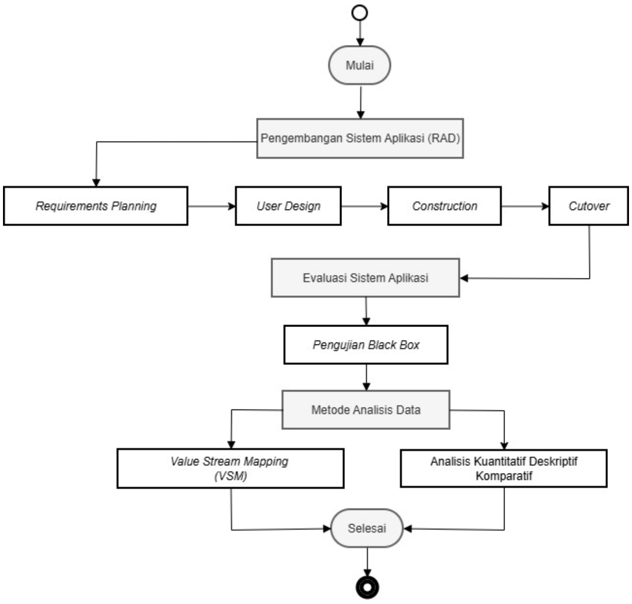

Figure 1. Reserch Flow

The research methodology was conducted through four systematic phases:

1. Research Initiation: Identified operational inefficiencies in resource management at the ICT workstation of PT. XYZ, followed by defining the research objectives and scope.
2. System Development (RAD Methodology):
   a. Requirements Planning: Gathered system requirements through in-depth interviews with the Industrial Engineering (IE) team and Gemba Walk observations, while constructing the Current State Map (CSM) via Value Stream Mapping (VSM) to identify value-added and non-value-added activities.
   b. User Design: Developed database architecture (ERD), system models (UML), and interactive user interface/experience (UI/UX) prototypes iteratively with end-user involvement.
   c. Construction: Programmed the web-based system using ASP.NET MVC and SQL Server, automated the Bill of Materials (BOM) Explosion logic, and constructed the Future State Map (FSM).
   d. Cutover: Executed data migration, conducted user training, and evaluated system performance on the staging server.
3. System Evaluation: Verified system functionality through Black-Box Testing to ensure all modules operated accurately according to functional specifications.
4. Data Analysis and Conclusion: Evaluated work time efficiency using a comparative quantitative approach by contrasting the current state (manual Excel workflow) against the future state (web-based system) using VSM analytics, culminating in the final synthesis of research findings.

C. System Development Methodology (RAD)

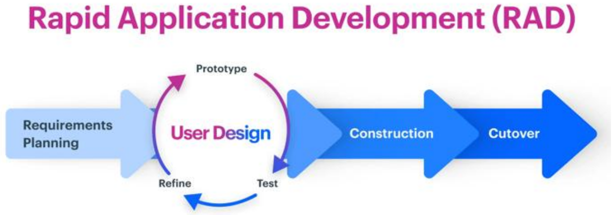

Figure 2. Rapid Application Development

Based on the RAD process stages outlined above, system testing is conducted iteratively with the IE team to ensure that the application is completed quickly and meets field requirements right away. The system was developed using the Rapid Application Development (RAD) methodology, which comprises four primary phases [9], [10]:

1. Requirements Planning: Gathering requirements through in-depth interviews and field observations (Gemba Walk) with the Industrial Engineering (IE) team, alongside the mapping of the Current State Map (CSM).
2. User Design: Designing interactive user interface/user experience (UI/UX) prototypes, Unified Modeling Language (UML) modeling (Use Case and Activity Diagrams), and Entity-Relationship Diagram (ERD) architecture.
3. Construction: The software development phase utilizing ASP.NET MVC (C#), SQL Server database implementation, automation of Bill of Materials (BOM) Explosion logic, and Black-Box testing execution.
4. Cutover: Data migration, user training, system evaluation on the testing server, and the construction of the Future State Map (FSM).

D. System Overview

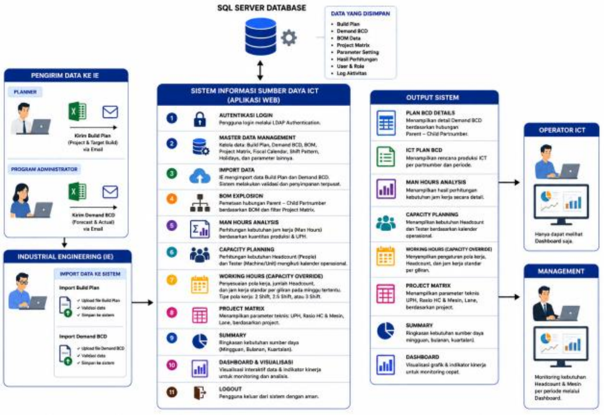

Figure 3. System Flow Overview

The figure above illustrates the system architecture of the Resource Information System at the In-Circuit Testing (ICT) workstation in PT. XYZ, integrated with a SQL Server database and LDAP authentication. Operationally, the Planner transmits Build Plan data, while the Program Administrator sends Demand BCD data to the Industrial Engineering (IE) team via email. Subsequently, the IE team imports and validates the data within the system, managing supporting parameters such as the Project Matrix, Working Hours, and other operational configurations. Once the data is stored, the system automatically executes BOM Explosion, Man Hours Analysis, and Capacity Planning to calculate workforce (Headcount) and tester requirements based on production data and operational calendars. The system also features a Capacity Override function, enabling the IE team to adjust work patterns, headcount numbers, and working hours for specific periods according to operational needs.

The processed data is presented across various output modules, including Plan BCD Details, ICT Plan BCD, Man Hours Analysis, Capacity Planning, Summary, and Dashboard. ICT Operators are granted view-only access to the Dashboard for operational monitoring, whereas management utilizes the generated insights to support decision-making processes. Through this architecture, resource management becomes more integrated, accurate, and efficient.

E. Functional Requirements

Table 2. Functional Requirements

Code	Functional Requirements
F001	The system shall provide a User Authentication (Login) feature to verify user identities.
F002	The system shall provide a Master Data module to manage foundational data (Build Plan, Demand BCD, BOM, and Fiscal Calendar).
F003	The system shall provide a BCD Data Import feature (Forecast & Actual Tracker) without altering calculations for other periods.
F004	The system shall provide a Project Matrix module to manage technical parameters, including UPH, HC-to-Machine ratio, and production lines as calculation benchmarks.
F005	The system shall provide a Configuration module to set working hours, shift patterns, and other global operational parameters.
F006	The system shall automatically integrate Holidays data from the centralized system to synchronize working hour capacities.
F007	The system shall display Plan BCD Details and ICT Plan BCD to map Parent-Child Part Number relationships based on BOM data and matrix filters.
F008	The system shall dynamically calculate Capacity Planning (Tester and Headcount) aligned with the operational calendar.
F009	The system shall perform automated Man Hours Analysis based on production volume and production speed (UPH).
F0010	The system shall provide a macro-level Summary of resource requirements (Weekly, Monthly, and Quarterly).
F0011	The system shall present calculation results visually through an interactive Dashboard.
F0012	The system shall provide a Logout feature to terminate the active user session.

F. Non-Functional Requirements

Table 3. Non-Functional Requirements

Parameter	Non-Functional Requirements
Usability	All user interfaces, error messages, and system documentation shall be presented in a clear and easily understandable manner.
Security	The system shall protect data against unauthorized access through login mechanisms and Role-Based Access Control (RBAC).

Performance	Pages displaying large datasets (e.g., demand tables) shall implement server-side processing techniques.
Language	The system interface shall utilize the English language.

G. Use Case Diagram

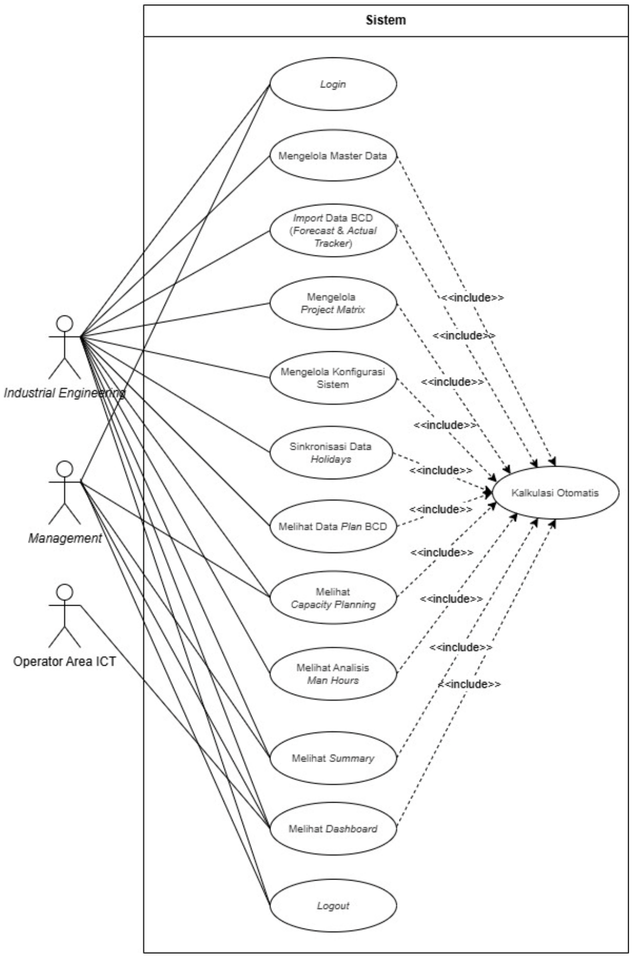

Figure 5. Use Case Diagram

User interactions are formalized into the Use Case Diagram in Figure 3, which illustrates the system functionality modeling by linking three primary actors (Industrial Engineering, Management, and ICT Area Operators) with 12 functional modules. Through this modeling, role-based access control is clearly defined: the IE team retains full authority over data processing and capacity interventions, management accesses executive analytics, and operators monitor operational status via dashboard displays.

H. Entity Relationship Diagram

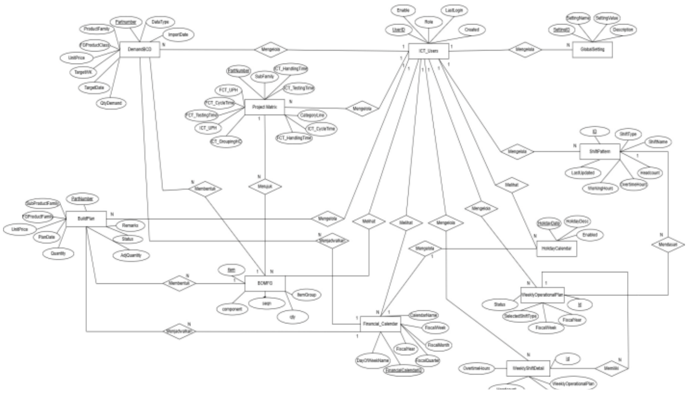

Figure 4. Entity Relationship Diagram

The relational database architecture of the system is structured around 11 integrated primary entities designed to automate resource allocation calculations. System security and user verification are managed through the ICT_Users entity to enforce Role-Based Access Control (RBAC). On the technical manufacturing front, the Project Matrix entity serves as a core benchmark storing product specifications such as Units Per Hour (UPH), Testing Time, and Handling Time while the BOMFG entity maps Parent-Child Part Number structures essential for executing BOM Explosion logic. Production planning data are partitioned into DemandBCD, which holds projected forecast quantities (specifically filtered for "Can Do" categories), and BuildPlan, which manages confirmed daily execution schedules. Operational time mapping and available man-hour calculations are dynamically derived from Financial_Calendar, HolidayCalendar, ShiftPattern, WeeklyOperationalPlan, and WeeklyShiftDetail, enabling granular adjustments to working hours, shift patterns, and overtime allocations. Finally, all system-wide parameters and constant variables are centralized within the GlobalSetting entity, providing operational flexibility without requiring hard-coded software modifications.

I. Materials and Tools

The technical specifications supporting this study comprise hardware components, including a developer laptop and a testing server (Intel Core i5 6th Gen, 8GB DDR4 RAM, 256GB SSD, and 64-bit Windows 10 Pro), alongside networking hardware (Router/Switch). The software architecture utilizes Microsoft Visual Studio 2022, Microsoft SQL Server Management Studio (SSMS), C#, HTML/CSS/JavaScript, Draw.io/PlantUML, and Figma.

J. Analysis Plan

The analysis plan in this study aims to evaluate the operational efficiency level, both in terms of processing time and workflow, prior to and following the implementation of the Resource Information System at the In-Circuit Testing (ICT) workstation in PT. XYZ. This evaluation is conducted using a comparative descriptive quantitative approach, employing Value Stream Mapping (VSM) as the primary analytical instrument. VSM serves to map, measure, and compare two distinct operational states: the current state, representing the manual Excel-based workflow, and the future state, representing the automated process facilitated by the web-based information system [11], [12].

The analysis is structured across three primary phases: data collection, data processing, and result interpretation.

1. **Data Collection and Parameter Classification Phase**

   Data collection was performed through direct observation (Gemba Walk) of user activities within the ICT workstation, accompanied by execution time logging using time-study stopwatches and system event logs. The primary observed activities include:

   a. Receiving demand data from related departments.
   b. Inputting demand and supporting operational data into Microsoft Excel spreadsheets.
   c. Adjusting calculation parameters (number of shifts, daily working hours, and labor efficiency).
   d. Executing workforce (headcount) requirement calculations via Excel formulas.
   e. Verifying calculation outputs and checking total working hour alignment.

   Time measurements were conducted to derive three key time metrics:

   a. Cycle Time (CT): The duration of active, dedicated work time spent processing and completing a specific operational task, measured from the initiation point to the final information output.
   b. Waiting Time (WT): The duration of passive idle time or delays between process stages, such as document transmission via email or passive computational delays caused by spreadsheet malfunctions (e.g., freezing or "Not Responding" errors during BOM expansion).
   c. Lead Time (LT): The comprehensive cumulative time from initial data collection to the visualization of tester capacity projection ratios, formulated as:

   $$LT = \sum(CT_i + WT_i)$$

   Operational activities are classified into three categories of information flow waste:

   a. Value-Added (VA): Core activities that directly transform raw data into essential strategic information for operational decision-making (e.g., engineering analysis and overtime hour simulations).
   b. Value-Enabling (VE / NNVA): Essential supporting activities that are technically required to execute VA tasks (e.g., uploading files into the system or backend computation of BOM expansion).
   c. Non-Value-Added (NVA / Waste): Activities that consume time and resources without contributing value (e.g., manually searching for historical UPH files, checking printed holiday calendars, and repeatedly generating manual report charts).

2. **Data Processing Techniques and Efficiency Formulas**

   The collected measurement data were analyzed through the following structured procedures:

   a. Current State Map (CSM): Visually mapping the sequence of manual Excel-based activities alongside their actual CT, WT, and LT values.
   b. Future State Map (FSM): Visually mapping the automated digital workflow following the implementation of the web-based system.
   c. Calculation of Efficiency Indicators:

      1. **Mean Processing Time (Descriptive Analysis):**

         $$\bar{X} = \frac{\sum X_i}{n}$$

         where $\bar{X}$= represents the mean process time, X_i= denotes the -i observed duration, and n=represents the total number of observations.

      2. **Time Savings Difference (Comparative Analysis):**

         $$\Delta T = T_{manual} - T_{sistem}$$

         where ΔT= represents net time savings, T_{manual}= is the total manual process time (T_{manual}), and T_{sistem}= is the total system process time T_{sistem}.

 e-ISSN: 2548-6861

3. Time Efficiency Percentage (E):

$$E = \left(\frac{\Delta T}{LT_{manual}}\right) \times 100\%$$

4. Value-Added Ratio (VAR):

$$VAR = \frac{\text{Total Waktu Aktivitas Bernilai Tambah (VA)}}{\text{Total Lead Time (LT)}} \times 100\%$$

A higher VAR indicates a more efficient process, reflecting an increased proportion of time dedicated to value-added activities.

3. Descriptive Comparative Analysis and Discussion Phase

This phase aims to interpret quantitative data comparisons through a descriptive comparative lens. Descriptive analysis characterizes average calculation times, total Lead Time, and VAR metrics. Comparative analysis evaluates operational shifts between manual and digital states based on ΔT and E. If Lead Time and Waiting Time decrease significantly while VAR increases substantially, the information system is empirically validated as effective and efficient in enhancing workforce and tester management productivity at the ICT workstation of PT. XYZ.

III. RESULT AND DISCUSSION

A. Implementation Results

The web-based Resource Information System was successfully implemented using the ASP.NET MVC framework and SQL Server database. Developed within Microsoft Visual Studio 2022 and SQL Server Management Studio (SSMS), the application was deployed on a staging server for user testing and operational validation with the Industrial Engineering (IE) team at PT. XYZ. The system digitalizes and automates headcount calculations, tester allocation, and BOM explosion logic effectively replacing previous manual Excel-based workflows to mitigate human errors and enhance operational efficiency. To maintain a concise presentation in accordance with publication guidelines, the core functional interfaces demonstrating the system's primary capabilities are highlighted below:

1. Main Dashboard & Executive Summary

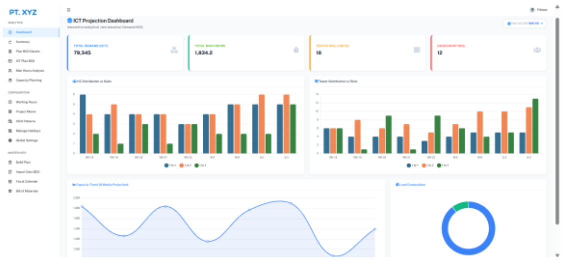

Figure 6. Dasboard

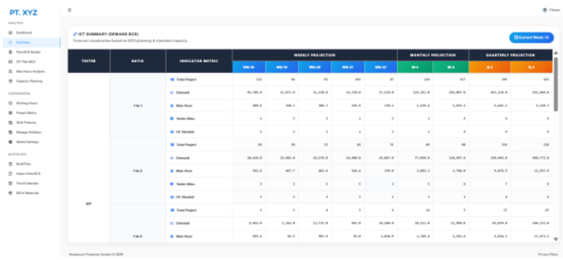

Figure 7. Summary

This figure illustrates the core operational interfaces of the system, comprising the Main Projection Dashboard and the Executive Summary Module. As shown in Figure 6, the dashboard functions as a real-time monitoring center that aggregates key operational metrics including total product demand, calculated workload (in man-hours), required tester units, and headcount allocations retrieved dynamically from the SQL Server database. The interface integrates interactive bar charts, line graphs, and donut charts to visualize rolling capacity projections across an 8-week horizon. Complementing this visual tracking, Figure 7 displays the consolidated Executive Summary, which categorizes capacity metrics across weekly, monthly, and quarterly timelines based on operational deployment ratios (e.g., 1:1, 1:2, and 1:3 tester-to-operator assignments). By replacing manual report generation, this integrated interface provides management with immediate visibility into long-term resource bottlenecks and productivity trends.

2. Man-Hours Analysis & BOM Explosion

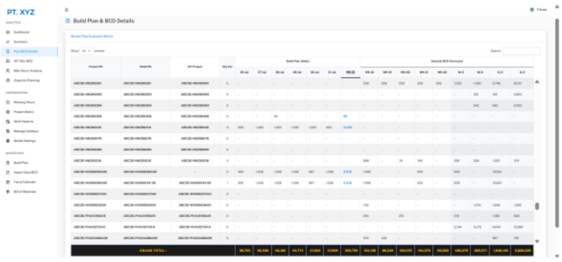

Figure 8. BOM Explosion

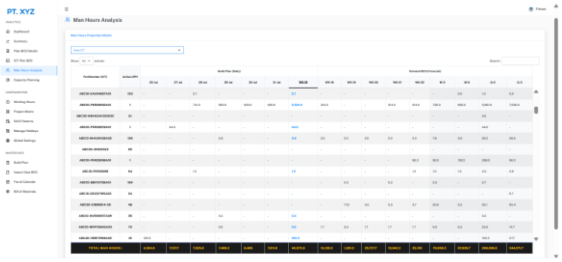

Figure 9. Man Hours Analysis

The primary processing engine of the developed system is presented in this figure, which highlights the Build Plan & BCD Details alongside the Man-Hours Analysis module. Figure 8 demonstrates the automated Bill of Materials (BOM) Explosion, where the system queries parent-child part number relationships from the relational database to decompose finished good demands into individual PCBA component requirements. Subsequently, as shown in Figure 9, the Man-Hours Analysis module converts these component production volumes into precise labor hours by applying active Units Per Hour (UPH) rates derived from the Project Matrix. Unlike spreadsheet calculations that were prone to computational freezes and formula errors during large-scale data mapping, this automated backend calculation executes instantly, establishing a transparent and error-free workload baseline for downstream capacity planning.

3. Capacity Planning & Tactical Override

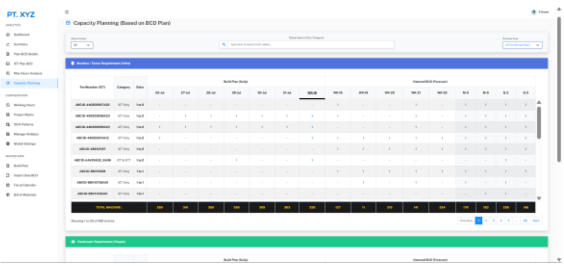

Figure 10. Machine / Tester Requirement (Units)

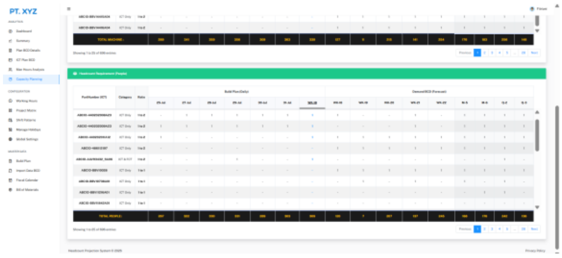

Figure 11. Headcount Requirement (People)

Figure 12. Working Hours

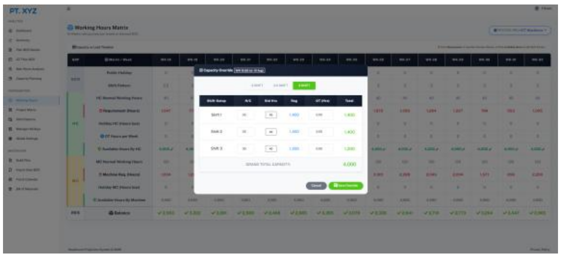

Figure 13. Tactical Override

The Figure depicts the Capacity Planning Module and its tactical intervention feature, the Modal Capacity Override. As illustrated in Figure 10, the module dynamically calculates the net requirements for testing machines and operational headcount by evaluating total workload against effective working hours, automatically deducting factory public holidays and non-working days. To accommodate real-time shop-floor dynamic changes, Figure 13 shows the Capacity Override modal, which enables Industrial Engineering (IE) personnel to adjust shift patterns (e.g., transitioning between 2-shift, 2.5-shift, or 3-shift configurations), headcount counts, and overtime allowances for specific fiscal weeks. Upon saving, the system re-evaluates capacity balances instantaneously without a full page reload, offering an agile framework for balancing line utilization and eliminating line idle time.

B. System Testing (Black-Box Testing)

All 14 Black-Box test scenarios (F001–F012) achieved a 100% pass rate, confirming that the automated execution of

BOM Explosion, Man-Hours Analysis, Capacity Planning, and Capacity Override functions operated with absolute precision. The detailed verification results are summarized in Table

Code	Test Scenario	Input & Action	Verification & Result	Status
F001	Valid Login	Input valid IE credentials & click "Login"	Verified via LDAP API; redirected to Dashboard	Pass
F001	Invalid Login	Input wrong password or blank fields	Access denied; error warning message displayed	Pass
F002	Master Data	Select BOM or Fiscal Calendar	Product hierarchy rendered from SQL Server	Pass
F003	Import BCD	Select local Excel file & click "Upload"	Parsed & inserted into DemandBCD without error	Pass
F004	Project Matrix	Input Part No, UPH, Testing Time	Validated as numeric and stored in ProjectMatrix	Pass
F005	Shift & Settings	Edit headcount/overtime & click "Save"	Updated in ShiftPattern; working hours rendered	Pass
F005	Capacity Override	Modify shift in modal & save override	Available hours updated in green in real-time	Pass
F006	Sync Holidays	Access Manage Holidays page	National holiday list loaded to deduct capacity	Pass
F007	BOM Explosion	Access Plan BCD Details page	Parent-Child PN exploded automatically	Pass
F008	Capacity Plan	Access Capacity Planning page	Net tester & headcount calculated dynamically	Pass
F009	Man-Hours	Apply production line filter	Labor hours converted via Volume/UPH formula	Pass
F010	Macro Summary	Select time filter (WK/M/Q)	Macro metrics aggregated across lines	Pass
F011	Dashboard	Access main Dashboard page	Charts & indicators rendered in real-time	Pass
F012	Logout	Click user profile & click "Logout"	Session invalidated; redirected to Login page	Pass

C. Value Stream Mapping (VSM) Analysis

1. Value Stream Map (VSM) Analysis – Current State

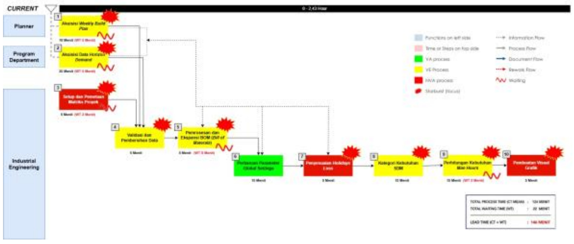

Figure 14. Value Stream Mapping Current State

Figure 14 depicts the Current State Map (CSM) representing the conventional resource management workflow at the In-Circuit Testing (ICT) workstation. The baseline evaluation reveals a substantial Process Lead Time of 146.00 minutes (2.43 hours), consisting of 124.00 minutes of active Cycle Time (CT) and 22.00 minutes of cumulative Waiting Time (WT) across 10 operational steps. The manual process is severely hindered by systemic operational wastes across departments (Planner, Program Department, and Industrial Engineering):

a. Communication & Inter-Departmental Delays (WT = 10.00 min): Asynchronous document transmissions via personal email for the Weekly Build Plan (Step 1) and Demand BCD Horizon data (Step 2) induce significant waiting waste (5.00 minutes each) before data collection can commence.
b. Motion Waste & Unintegrated Files (Step 3: CT = 5.00 min, WT = 2.00 min): IE engineers spend unnecessary time manually locating historical UPH draft files stored in local directories.
c. Technical Computation Delays (Step 5: CT = 5.00 min, WT = 8.00 min): Executing manual VLOOKUP functions across thousands of rows to explode the Bill of Materials (BOM) causes frequent application freezes ("Not Responding" errors), introducing an 8-minute computational delay.
d. Non-Value-Added Clerical Activities (Steps 7 & 10: CT = 10.00 min): Manually checking printed company calendars to deduct holiday capacity loss (Step 7) and manually re-creating bar charts in Excel for

e-ISSN: 2548-6861

every weekly reporting cycle (Step 10) constitute pure over-processing waste.

e. Formula Rework Waste (Step 9: WT = 2.00 min): Manually entering spreadsheet formulas often triggers calculation errors (such as #DIV/0! or #N/A), forcing engineers to spend additional time troubleshooting broken formulas.

Overall, the manual workflow is heavily dominated by clerical administrative tasks and non-value-added activities, severely limiting the agile execution of capacity planning.

2. Value Stream Map (VSM) Analysis – Future State

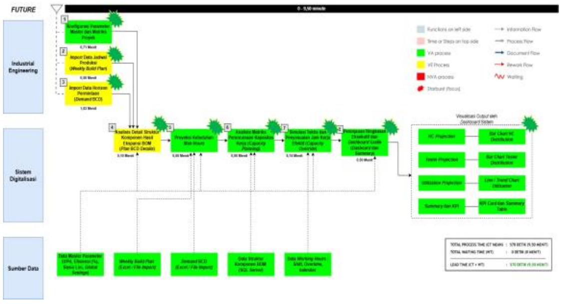

Figure 15. Value Stream Mapping Future State

Figure 15 illustrates the Future State Map (FSM) following the implementation of the web-based Resource Information System powered by ASP.NET MVC and SQL Server. The digital transformation restructures the end-to-end information flow, consolidating data management across Industrial Engineering, System Backend, and Central Data Sources into an 8-step streamlined workflow. Key operational improvements captured in the Future State Map include:

a. Total Elimination of Waiting Time (WT = 0.00 min): Centralizing data within a unified SQL Server database completely removes inter-departmental email delays, file transfer waiting times, and application freeze delays.

b. High-Speed Backend Computation (Steps 4–6: Total CT = 0.21 min / 12.80 s): Relational database queries handle complex BOM Structure Explosions (Step 4: 6.00 s), Man-Hours workload calculations (Step 5: 3.30 s), and initial Capacity Planning grouping (Step 6: 3.80 s) near-instantaneously, eliminating all manual VLOOKUP operations and formula error debugging.

c. Shift Toward Strategic Value-Added Analysis (Step 7: CT = 5.74 min / 344.60 s): Rather than spending time on clerical file maintenance, the majority of the user's active cycle time is redirected toward high-value cognitive engineering tasks specifically executing tactical shift, headcount, and overtime simulations via the interactive Capacity Override modal.

d. Automated Executive Dashboard Rendering (Step 8: CT = 0.50 min / 30.00 s): All key performance indicators including Headcount Projections, Tester Projections, Utilization Trend Lines, and KPI Summary Cards are auto-rendered in real-time without requiring manual graph compilation.

As a result, the total Process Lead Time is drastically reduced from 146.00 minutes down to just 9.50 minutes (570.00 seconds), while pure Non-Value-Added (NVA) activities are completely eradicated (0.00%).

3. Comparative Efficiency Analysis

To quantify the operational efficiency gained through the web-based system, a comparative analysis was performed by measuring process metrics against the manual Excel baseline. Table III summarizes the average Cycle Time (CT) reduction across all primary operational activities.

Table 4. Activity-Wise Processing Time Comparison

Activity	Manual (min)	System (min)	ΔT (min)	Key Improvement
Master and Matrix Config	5.00	0.71	4.29	Centralized database parameters setup
Weekly Build Plan Import	18.00	0.50	17.50	Direct file upload vs email transfers
Demand BCD Import	36.00	1.83	34.17	Automated file parsing & validation

BOM Explosion Analysis	5.00	0.10	4.90	Instant SQL query execution
Man-Hours Workload Review	15.00	0.05	14.95	Automated calculation without formula errors
Capacity Planning Matrix	15.00	0.06	14.94	Dynamic grouping of testers and headcount
Tactical Shift/OT Simulation	25.00	5.74	19.26	Interactive Capacity Override feature
Dashboard & Executive Review	5.00	0.50	4.50	Real-time KPI chart rendering
Total:	124	9.50	114.5	Massive overall efficiency gain

4. Efficiency Indicator Calculations

Presentation of the results of numerical calculations based on the efficiency formulas defined in Chapter II (Methodology):

a. Total Lead Time

The total cycle time (Process Lead Time) is calculated by adding the average cycle time to the waiting time.

$$T = \sum(CT_i + WT_i)$$

$$\mathrm{LT_{manual}} = 124{,}0 + 22{,}0 = 146{,}0 \text{ Minute}$$

$$\mathrm{LT_{system}} = 9{,}50 + 0{,}00 = 9{,}50 \text{ Minute}$$

b. Work Time Difference (ΔT)

The net time savings after implementing the web-based information system are calculated using the following comparative analysis formula.

$$\Delta\mathrm{T} = \mathrm{LT_{manual}} - \mathrm{LT_{system}}$$

$$\Delta\mathrm{T} = 146{,}0 - 9{,}50 = 136{,}50 \text{ Minute}$$

c. Time Efficiency Percentage (E)

The percentage increase in operational work time efficiency following the implementation of an information system is calculated by dividing the time difference by the total time spent on manual processing.

$$\mathrm{E} = \left(\frac{\Delta\mathrm{T}}{\mathrm{LT_{manual}}}\right) \times 100\%$$

$$\mathrm{E} = \left(\frac{136{,}50}{146{,}0}\right) \times 100\% = 93{,}49\%$$

d. Value Added Ratio (VAR)

The value-added activity ratio is calculated to measure process efficiency by comparing the total cycle time of value-added activities to the total lead time.

$$\mathrm{VAR} = \left(\frac{\sum \mathrm{CT_{Value\ Added}}}{\mathrm{LT}}\right) \times 100\%$$

1. Manual Activity Ratio

$$\sum \mathrm{CT_{VA\ Manual}} = 15{,}0 \text{ Minute}$$

$$\mathrm{VAR_{manual}} = \left(\frac{15{,}0}{146{,}0}\right) \times 100\% = 10{,}27\%$$

2. System Activity Ratio

$$\sum \mathrm{CT_{VA\ System}} = 42{,}4 + 3{,}3 + 3{,}8 + 344{,}6$$
$$+ 30{,}0 = 424{,}1 \textit{ Second}$$
$$= 7{,}07 \text{ Minute}$$

$$\mathrm{VAR_{system}} = \left(\frac{7{,}07}{9{,}50}\right) \times 100\% = 74{,}42\%$$

5. Comparison Charts

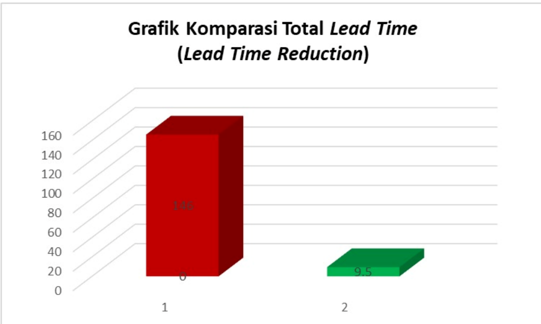

Figure 16. Total Lead Time Comparison Chart

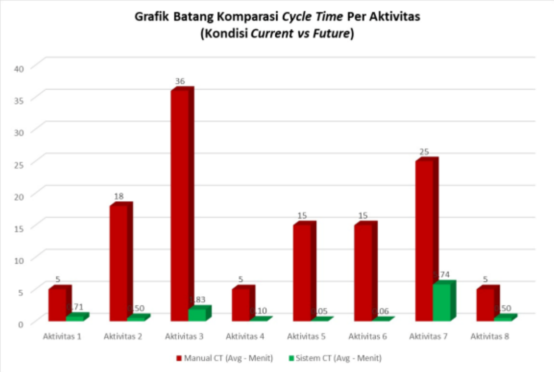

Figure 17. Comparison Bar Chart of Cycle Times by Activity

The comparative Value Stream Mapping (VSM) analysis empirically demonstrates that digitalizing the capacity planning process drastically reduces Process Lead Time from 146.00 minutes in the current state to 9.50 minutes in the future state. Centralized database integration alongside automated part number validation completely eliminates manual data acquisition delays and formula revisions, thereby maximizing Process Cycle Efficiency (PCE). Ultimately, this digital transformation secures absolute data integrity while enabling management to execute agile, precise, and data-driven workforce allocations and capacity balancing at the In-Circuit Testing (ICT) workstation.

6. **Comparative Current and Future State Analysis**

The digital transformation from the manual spreadsheet-based process to the web-based information system yields significant operational improvements across three critical domains:

a. Total Elimination of Waiting Time (WT): Inter-departmental email delays and manual query typing obstacles, which accounted for 22.00 minutes of Waiting Time in the current state, were completely reduced to 0.00 minutes in the future state through centralized SQL Server database integration.

b. Substantial Value-Added Ratio (VAR) Optimization: The system elevated the VAR from 10.27% to 74.42%. Pure Non-Value-Added (NVA) activities were entirely eradicated (0.00%), while Value-Enabling (VE) tasks were reduced from 94.00 minutes to 2.43 minutes via backend query automation. Consequently, user workload effectively shifted toward high-value cognitive decision-making, such as executing tactical capacity simulations using the Capacity Override feature.

c. System Stability and Reliability (8-Week Evaluation): Time-series evaluations across an 8-week monitoring period demonstrated high system reliability, maintaining tight operational durations between 9.20 minutes (Test 6) and 9.77 minutes (Test 7), yielding an average Process Lead Time (LT_{system}) of 9.50 minutes. Compared against the manual baseline (LT_{manual} = 146.00 minute), the system achieved a net time savings (ΔT) of 136.50 minutes per planning cycle, representing a time efficiency percentage (E) of 93.49%.

IV. CONCLUSION

Based on the implementation and comparative evaluation of the web-based Resource Information System at the In-Circuit Testing (ICT) workstation of PT. XYZ, several primary conclusions are drawn:

1. **System Development and Functional Verification**

A web-based Resource Information System was successfully developed using the Rapid Application Development (RAD) methodology, built upon ASP.NET MVC framework and SQL Server database. The system fully automates critical operations including Bill of Materials (BOM) Explosion, Man-Hours Analysis, dynamic Capacity Planning, and tactical Capacity Override. Black-Box testing verified a 100% pass rate across all 14 functional test scenarios, proving high system precision and eliminating manual data entry risks.

2. **Process Lead Time and Efficiency Gain**

Value Stream Mapping (VSM) analysis demonstrates that digitalizing the planning workflow drastically reduced total Process Lead Time by 93.49%, decreasing from a manual baseline of 146.00 minutes down to 9.50 minutes in the future state. Time-series observations over an 8-week period confirmed high operational stability, maintaining consistent cycle times between 9.20 and 9.77 minutes and yielding a net time savings (ΔT) of 136.50 minutes per planning cycle.

3. **Workflow Waste Elimination and VAR Elevation** Centralized relational database integration completely eliminated inter-departmental Waiting Time (from 22.00 minutes to 0.00 minutes) and eradicated pure Non-Value-Added clerical waste. This transformation propelled the Value-Added Ratio (VAR) from 10.27% to 74.42%, successfully shifting the engineers' workload from administrative data preparation toward agile, data-driven decision-making and capacity balancing on the lane production.

ACKNOWLEDGMENTS

The author would like to express sincere gratitude to Politeknik Negeri Batam and PT. XYZ for providing the academic platform, research environment, and operational support necessary to conduct this study. Special appreciation is extended to Mr. Noper Ardi, S.Pd., M.Eng., as the academic supervisor, and Mr. Supardianto, M.Eng., Head of the Software Engineering Technology Study Program, for their invaluable guidance, constructive insights, and continuous encouragement throughout the completion of this research.

The author also conveys heartfelt thanks to Mr. Syahrul Amri, Mr. Azis Mujianto, Mr. Karles Sinaga, and Mr. Agung Nugraha for their technical mentorship, practical guidance, and operational assistance during the field observations and system evaluation at the In-Circuit Testing (ICT) workstation.

REFERENCES

[1] B. Zhang, W. Dong, and J. Yao, "The Digital Transformation of the Manufacturing Industry, the Double-Factor Allocation Efficiency of the Manufacturing Industry, and Carbon Emissions: Evidence from China," Scientific Reports, vol. 15, no. 1, pp. 1–26, 2025.

[2] K. Wu, S. Liu, M. Zhu, and Y. Qu, "The impact of digital transformation on resource mismatch of Chinese listed companies," Scientific Reports, vol. 14, no. 1, pp. 1–12, 2024.

[3] M. Filz, J. P. Bosse, and C. Herrmann, "Digitalization platform for data-driven quality management in multi-stage manufacturing systems," Journal of Intelligent Manufacturing, vol. 35, no. 6, pp. 2699–2718, 2024.

[4] A. R. G. Abimanyu, B. T. Hanggara, and A. Pinandito, "Analisis Komparatif Data Presensi: Studi Perbandingan Efisiensi Antara Metode Manual Dan Sistem Informasi Berbasis Web Di CV. Griya Facade," Jurnal Pengembangan Teknologi Informasi dan Ilmu Komputer, vol. 9, no. 7, pp. 1–10, 2025.

[5] A. E. Isprasetia, I. Nurmalasari, A. Surya, D. Ramdani, and A. Setiawan, "Pengaruh Sistem Informasi Manajemen Rumah Sakit (SIMRS) terhadap Efisiensi Waktu Tunggu Pasien Rawat Jalan," Jurnal Kesehatan Masyarakat, vol. 5, no. 8, pp. 2533–2547, 2025.

[6] B. R. Pratama, I. Arwani, and Tibyani, "Pengembangan Sistem Informasi Manufaktur Air Minum Untuk Meningkatkan Efisiensi Pengelolaan Bahan Baku," Jurnal Teknologi Informasi dan Perangkat Lunak, vol. 9, no. 7, pp. 1–9, 2025.

[7] A. S. Patil, M. V. Pisal, and C. T. Suryavanshi, "Application of value stream mapping to enhance productivity by reducing manufacturing lead time in a manufacturing company: A case study," International Journal of Lean Six Sigma, vol. 19, no. 2, pp. 11–22, 2021.

[8] Noviyana, M. H. Abdullah, A. J. Suwondo, and O. A. W. Riyanto, "PENERAPAN LEAN MANUFACTURING DENGAN METODE VALUE STREAM MAPPING (VSM) UNTUK MENINGKATKAN PRODUKTIFITAS (STUDI KASUS: PT. XYZ)," Jurnal Teknik Industri, vol. 3, no. 1, pp. 215–230, 2024.

[9] M. A. Fauzi, H. Tribiakto, A. Moniva, and F. Amir, "Systematic Literature Reviews on Rapid Application Development Information System," Building of Computer Science and Electrical Engineering (BCSEE), vol. 4, no. 1, pp. 57–64, 2023.

[10] R. I. Handayani and D. A. Astuti, "Application of the Rapid Application Development Model to a Web-Based Library Information System," Informatics and Software Engineering, vol. 1, no. 2, pp. 68–76, 2023.

[11] S. Arunizal, D. H. Wardhani, and J. Windarta, "Penerapan Value Stream Mapping (VSM) untuk Menurunkan Lead Time Process dan Meningkatkan Kinerja Aktivitas Pengadaan di Site Tambang," Jurnal Energi dan Manufaktur, vol. 2, no. 3, pp. 141–150, 2024.

[12] S. Dwima Saputro, S. Faizah, N. Afriyani Ramdani, D. Andika, and R. Aditya Gunawan, "IMPLEMENTATION OF VALUE STREAM MAPPING TO INCREASE PT RCI'S PRODUCTIVITY AND EFFICIENCY," Journal of Industrial Engineering & Management Research, vol. 7, no. 3, pp. 8795–8803, 2024.