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Regular Research Article

Improving the Efficiency of Oil and Gas Asset Handling in the Receiving Process at an Oil & Gas Logistics Company

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Abstract: Warehouses play a strategic role in the oil and gas logistics industry, particularly in the receiving process as the initial stage of asset management. This study was conducted at the Oil & Gas Logistics Co. warehouse to identify and reduce non-value-added activities (waste) through the implementation of a Lean Service approach. The analysis examined the proportions of Value-Added (VA), Non-Value-Added (NVA), and Necessary but Non-Value-Added (NNVA) activities, and proposed improvements aimed at enhancing process efficiency and warehouse performance. The methods employed included Value Stream Mapping (VSM), a Seven Waste questionnaire, Value Stream Analysis Tools (VALSAT), Process Activity Mapping (PAM), and Root Cause Analysis (RCA) using a fishbone diagram. The results indicated that the dominant waste in the receiving process was due to waiting/delays (21%) and overprocessing (19%). The implementation of Lean Service reduced lead time from 1,173.78 minutes to 1,018.50 minutes (approximately a 13% efficiency improvement) and decreased the proportion of NVA from 12.14% to 3.22%. This reduction of 155.28 minutes per cycle corresponded to labor cost savings of approximately Rp128,706 per cycle. Overall, the implementation of Lean Service improves operational efficiency, supports the achievement of warehouse KPIs, and provides significant economic benefits with a high Return on Investment (ROI), making it a potential model for continuous improvement in oil and gas logistics as well as other logistics sectors.

Keywords: receiving, lean service, VALSAT, NVA, warehouse, oil and gas assets

1. Introduction

Warehouses play a crucial role in the oil & gas supply chain as temporary storage facilities to ensure the availability and quality of spare parts, supporting asset operations and maintenance. Oil & Gas Logistics Co manages warehousing activities including receiving, storage, and shipping [1][2][3]. The receiving process, as part of inbound logistics, involves document inspection, physical verification, recording, and initial placement of goods. Despite a lead time KPI of three calendar days, challenges such as workforce constraints, volume fluctuations, and operational waste still occur, causing stock placement delays and disrupting operations [4][5][6]. This study analyzes and improves the receiving process using Lean Service through Value Stream Mapping (VSM) and Value Stream Analysis Tools (VALSAT), focusing on identifying dominant wastes were and designing a future state. The scope covers all stages up to the recording of the Good Receipt (GR), ensuring systemic impact on warehouse performance.

The objectives of this study are to understand the current receiving process flow, identify the types of waste at each stage, analyze factors hindering lead time achievement, and design a future state using Lean Service and VSM to reduce lead time and improve KPIs. The spare part receiving process occurs daily, from both international suppliers and local branches [6][7]. It is managed by a small team of two administrative staff, one staff member, and one operator, creating workload imbalance and

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potential waste such as unproductive waiting time, time-consuming searches for storage locations, and repetitive sorting and binning tasks [8].

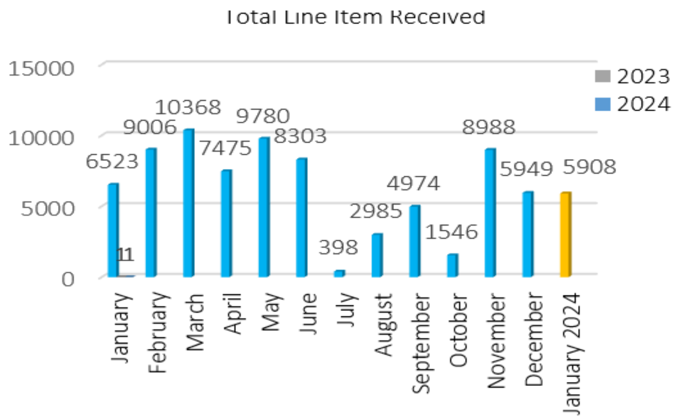

Figure 1. Total Penerimaan Spart Part [1]

The data in Figure 1 shows fluctuations in spare part receipts, which can create bottlenecks and delays in the receiving process. To better understand these operational challenges, Figure 2 presents a detailed workflow of the receiving process at Oil & Gas Logistics Co., illustrating the seven stages from manifest checking to Good Receipt (GR). This mapping highlights task sequences and dependencies that influence lead time, providing the foundation for identifying waste and designing Lean Service improvements. A systematic approach is required to identify and eliminate wastes, thereby improving performance and KPI achievement [9].

Implementing Lean Warehouse principles, as practiced at PT. ABC, can guide Water Resources Management at UNHAS in managing resources more effectively. This ensures that the receiving process meets the three-day lead time, supports warehouse KPIs, and maintains the availability of spare parts for oil & gas operations [8][10][11].

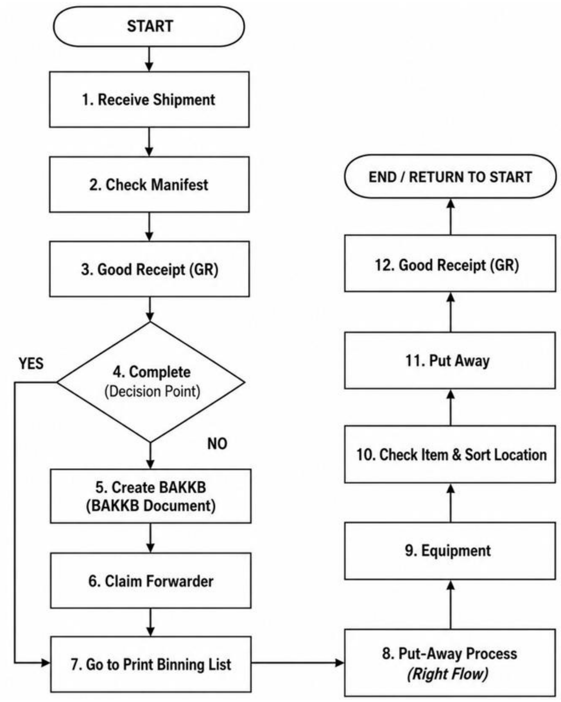

Figure 2. Flow chart of Receiving Oil & Gas Logistics Co [2]

Figure 2 shows the receiving process flow, consisting of seven stages: manifest checking, unloading, printing the binning list, preparation of equipment, item inspection and sorting, put-away, and Good Receipt (GR). A study by Mollah, Munir, and Sari (2022) in the transportation

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sector (PT KAI Daop 8 Surabaya) reduced lead time from 2,035 to 1,901 seconds without cutting value-added activities of 1,454 seconds [12]. While Lean Service has proven effective in transportation, its application in oil & gas logistics receiving remains limited. The research gap lies in the lack of studies systematically integrating VSM and VALSAT to identify and prioritize wastes, and limited analysis of workforce-related waste affecting receiving lead time KPIs [13][14].

This study contributes by integrating Lean Service, VSM, and VALSAT to analyze waste, design a future state for spare part receiving, and provide actionable recommendations to enhance efficiency and reduce lead time. The novelty of this study is its focus on receiving as a critical inbound activity with a three-day lead time target, linking operational improvements directly to warehouse KPIs and financial performance through cost savings and ROI analysis [15]. Integrated Lean approaches in oil & gas logistics remain underexplored, making this study valuable both academically and practically for sustainable warehouse operations.

2. Materials and Methods

2.1 Research Design

This study employed a mixed-methods approach using a sequential explanatory design. Quantitative data were collected and analyzed first, followed by qualitative analysis to provide deeper insights into the quantitative findings. This design was selected to obtain a comprehensive understanding of the receiving process at Oil & Gas Logistics Co.'s warehouse. The mixed-methods approach was considered appropriate because the analysis of the receiving process requires not only the measurement of process performance in terms of time but also an understanding of the operational causes of waste. Therefore, this approach enables the identification of process cycle times, the classification of waste, and the interpretation of operational constraints in the field.

Quantitative data were used to measure process performance, including receiving lead time, the proportion of Value-Added (VA), Necessary but Non-Value-Added (NNVA), and Non-Value-Added (NVA) activities, as well as process efficiency. Meanwhile, qualitative data obtained through the Seven Waste Lean questionnaire and Root Cause Analysis (RCA) were used to explain the causes of waste and operational problems found in the receiving process.

2.2 Key Performance Indicators

The performance of the receiving process was evaluated using Key Performance Indicators (KPIs), which compare the condition before improvement, known as the current state, with the condition after improvement, known as the future state. The KPIs were established in accordance with the warehouse operational targets.

The main performance indicators used in this study include receiving lead time, the proportion of Value-Added (VA) activities, the proportion of Necessary but Non-Value-Added (NNVA) activities, the proportion of Non-Value-Added (NVA) activities, receiving process efficiency, and financial impact or cost saving. Receiving lead time refers to the total time required from the receipt of goods in the unloading area until the Good Receipt (GR) process is completed. In this study, the company sets a maximum receiving lead time of three calendar days as the main warehouse KPI. The proportion of Value-Added (VA) activities represents the percentage of time spent on activities that directly add value to the receiving process, while the proportion of Necessary but Non-Value-Added (NNVA) activities refers to activities that do not directly add value but are still required to support operational processes. In contrast, the proportion of Non-Value-Added (NVA) activities represents the level of waste in the receiving process and becomes the focus of improvement through Lean Service implementation. Receiving process efficiency is calculated by comparing the total lead time between the current state and the future state. Furthermore, the financial impact or cost saving refers to operational cost savings achieved through lead time reduction and the elimination of non-value-added activities, which are analyzed using the Activity-Based Costing (ABC) approach. These KPI indicators ensure that the proposed improvements not only enhance operational efficiency but also support warehouse targets and provide economic benefits.

2.3 Lean Service, VSM, and VALSAT

Lean Service was applied in this study to reduce repetitive non-value-added activities in

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the receiving process. Value Stream Mapping (VSM) was used to map the current state and design the future state to accelerate the flow of value in warehouse operations [16]. In addition, Value Stream Analysis Tools (VALSAT) were employed to classify activities based on their contribution to value creation [1]. Based on VALSAT, the activities in the receiving process were categorized into three groups: Value Added (VA), Necessary but Non-Value Added (NNVA), and Non-Value Added (NVA). Value Added activities refer to activities that directly contribute value to the product or service. Necessary but Non-Value-Added activities are activities that do not directly create value but are still required to support the operational process. Meanwhile, Non-Value-Added activities refer to wasteful activities that do not provide value and should therefore be minimized or eliminated to improve process efficiency.

2.4 Data Collection

Cycle time data were collected from 62 samples representing 38 sub-activities in the receiving process. Cycle time measurements were conducted using the time study or stopwatch study method through direct observation of each sub-activity. Each activity was measured under normal operational conditions to reflect actual process performance.

For repetitive activities, measurements were conducted more than once to capture variations in process time. The cycle time values used in the analysis represent the mean value of the measurements. Total receiving lead time was calculated as the cumulative sum of all activity cycle times from the unloading process until the Good Receipt (GR) process was completed.

The sample size was determined purposively by considering the representation of operational variations, including material type, material volume, process complexity, activity frequency, and process time variability. Therefore, the number of measurements for each activity was not uniform. Activities with higher variability were measured more frequently to improve data reliability. Based on this approach, 62 samples were considered sufficient to empirically represent the cycle time performance of the receiving process.

The data collection process was conducted through several integrated activities. First, direct observation was carried out across all stages of the receiving process, starting from goods receipt to the completion of the Good Receipt (GR) process. Second, the cycle time of each activity was recorded using a stopwatch to obtain accurate time measurements for each sub-activity. Third, a questionnaire based on the Seven Waste Lean principles was distributed to ten workers who were directly involved in the receiving process. This questionnaire was used to collect qualitative data regarding workers' perceptions of waste and operational constraints. Finally, 62 quantitative measurements representing 38 main sub-activities in the receiving process were collected to reflect variations in activity characteristics and actual operational conditions.

2.5 Research Procedure

The research procedure was designed systematically to ensure the consistent application of Lean Service, VSM, VALSAT, RCA, and cost analysis. The stages of the research procedure are described as follows:

2.5.1 Process Mapping

The complete receiving process flow was mapped using Value Stream Mapping (VSM). This stage aimed to identify the sequence of activities, the cycle time of each activity, and the classification of each activity into VA, NNVA, or NVA categories.

2.5.2 Waste Identification and Analysis

Waste identification was conducted using VALSAT by classifying each activity based on its value contribution. Weighted scores were assigned to determine the priority of the most significant types of waste. The percentage of time spent on NVA and NNVA activities was then calculated to identify areas requiring improvement. In the mixed-methods framework, quantitative and qualitative data complement each other. Quantitative data were used to measure process performance, while qualitative data obtained from questionnaires and RCA were used to explain the underlying causes of waste. The integration of both data types was conducted through VSM and VALSAT. Activities with high cycle times were further analyzed based on their root causes.

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2.5.3 Future State Design

Based on the findings from the current state analysis, a future state design was developed for the receiving process. The future state design focused on reducing lead time, eliminating waste, improving process flow, and increasing the achievement of warehouse KPIs. This stage ensured that the proposed improvements were not only based on quantitative data but also reflected actual operational conditions.

2.6 Cost Analysis Method

After designing the future state, a cost analysis was conducted to evaluate the economic impact of waste elimination using the Activity-Based Costing (ABC) approach. Each NVA and NNVA activity was assigned a cost estimate based on labor time, equipment or facility usage, and materials involved. The cost calculation was performed by multiplying the activity time by the resource cost rate used, resulting in an estimated cost for each activity. The results of the cost analysis were then used to calculate potential cost savings and determine economically prioritized improvements.

Cost analysis for each activity in the receiving process was measured using cycle time to obtain total lead time and provide a quantitative overview of process efficiency. The identified activities were then classified using VALSAT into VA, NNVA, and NVA categories, allowing the determination of waste areas requiring improvement. The integration of cost analysis ensures that the recommended improvements not only enhance operational efficiency but are also financially effective.

2.7 Root Cause Analysis

Root Cause Analysis (RCA) is a systematic method used to identify the underlying causes of problems, events, complaints, or discrepancies that occur in operational processes [17]. The main objective of RCA is to identify the root causes of a problem so that the proposed solutions are comprehensive and do not merely address symptoms [11].

One of the commonly used tools in RCA is the fishbone diagram, also known as the Ishikawa diagram. This diagram is used to visualize and analyze the factors causing a problem from several aspects, including man, machine, method, material, and environment [9]. By using the fishbone diagram, researchers can systematically group and evaluate potential causes of problems in the receiving process.

2.8 Data Integration

All quantitative data, including cycle time and lead time measurements, and qualitative data, including questionnaire results and RCA findings, were integrated using VSM and VALSAT. This integration was conducted to design the future state of the receiving process based on Lean Service principles, determine improvement priorities for the most significant wastes, and calculate potential cost efficiency.

The integration of quantitative and qualitative data provides a comprehensive basis for formulating actionable improvement recommendations. This approach is expected to reduce lead time, eliminate non-value-added activities, improve warehouse efficiency and KPI achievement, and prioritize improvements targeting the most significant sources of waste.

Table 1. Value Stream Analysis Tools (VALSAT) Matrix [1]

Waste	PAM	SCRPM	PVF	QFM	DAM	DPA	PS
Overproduction	L	M		L	M	M	
Waiting	H	H	L		M	M	
Transportation	H						L
Overprocessing	H		M	L		L	
Unnecessary Inventory	M	H	M		H	M	L
Unnecessary Motion	H	L					
Defect	L			H			

3. Result

3.1. Description of the Receiving Process

This study was conducted at Oil & Gas Logistics Co, a company specializing in the logistics and distribution of oil & gas industrial goods. One of the crucial processes in the company’s operations is receiving, which involves the acceptance of goods from suppliers for storage before distribution. This process

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comprises a series of activities that must be performed promptly to ensure the smooth flow of the supply chain.

According to initial observations, indications of waste were identified, such as high waiting times, inventory buildup, and non-value-added activities. To analyze these issues, the process was mapped using the Value Stream Mapping (VSM) method. VSM illustrates the flow of activities from manifest checking to the storage of goods in the warehouse. This mapping aims to identify process time (Cycle Time), waiting time (Lead Time), and potential waste in the receiving process. The analysis results showed a total time for Value-Added (VA) activities of 885.74 seconds, Non-Value-Added (NVA) activities of 145.56 seconds, and a total overall Lead Time of 1,132.3 seconds. Another analysis indicated total VA activity time of 885.74 minutes, NVA activity time of 142.48 minutes, and a total lead time of 1,173.78 minutes.

The process consists of seven main activities, each performed by a single person, with the highest inventory recorded at 305 units, indicating a potential bottleneck at that point. This condition suggests a flow imbalance, particularly in activities that depend on equipment availability and coordination between processes. After obtaining an overall picture from the process mapping, the process activities were identified by calculating cycle time as the primary performance indicator.

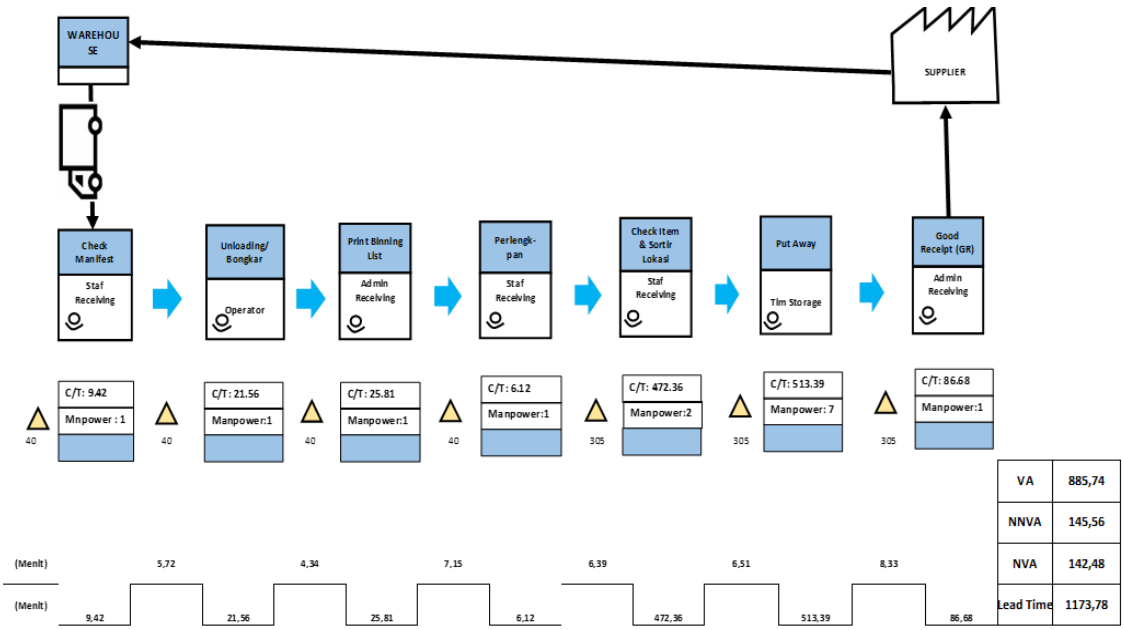

Figure 3. Future State Mapping of the Receiving Process [3]

3.2. Process Mapping Using VSM

The VSM mapping results illustrate the actual receiving process flow, while a waste questionnaire was used to identify dominant waste with respondents who are field experts. Each type of waste was weighted based on respondents' perceptions and validated using Value Stream Analysis Tools (VALSAT). The questionnaire results indicated that Waiting was the most dominant waste (score 22, weight 0.216), followed by Overprocessing (score 20, weight 0.196) and Transportation (score 15, weight 0.147), while Overproduction and Unnecessary Inventory had the lowest score of 0.098. The dominance of Waiting waste indicates significant idle time between activities, which directly contributes to the high lead time in the receiving process.

Based on the weighting results, Process Activity Mapping (PAM) obtained the highest score of 6.765, making it the most recommended Lean tool for further analysis. This indicates that an activity-based analysis approach is more effective in identifying waste compared to other tools that focus on information flow or process quality. This indicates that PAM is the most suitable tool to be applied for process improvement.

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Table 1. Selection of VALSAT Tools [2]

No.	Waste	PAM	SCRPM	PVF	QFM	DAM	DPA	PS
1	Overproduction	0.098	0.294		0.098	0.294	0.294	
2	Waiting	1.941	1.941	0.216		0.647	0.647	
3	Transportation	1.324						0.147
4	Overprocessing	1.765		0.588	0.196		0.196	
5	Unnecessary Inventory	0.294	0.882	0.294		0.882	0.294	0.098
6	Unnecessary Motion	1.235	0.137					
7	Defect	0.108			0.971			
	Total	6.765	3.255	1.098	1.265	1.824	1.431	0.245
	Ranking	1	2	6	5	3	4	7

Based on the Value Stream Analysis Tools (VALSAT), seven types of waste were evaluated to determine improvement priorities and the most appropriate Lean tools. The table shows the weighted scores of each waste and their suitability with various Lean tools, including Process Activity Mapping (PAM), Supplier-Consumer Relationship Process Mapping (SCRPM), Process Visualization Flow (PVF), Quality Flow Mapping (QFM), Detailed Activity Mapping (DAM), Data Processing Analysis (DPA), and Process Simplification (PS). The calculation results show that Waiting waste obtained the highest score (6.765) and is the top priority, followed by Overprocessing with a score of 3.25. This confirms that these two wastes should be the primary focus of process improvement. PAM and SCRPM are the most recommended tools, as they have the highest suitability scores for these types of waste. Meanwhile, wastes such as Defect and Unnecessary Motion have lower scores and are considered lower priorities. By selecting the appropriate tools, the company can focus on improving the most critical waste areas effectively. The chart below provides a visual comparison of the suitability scores of various Lean tools based on VALSAT analysis, facilitating the identification of priority interventions.

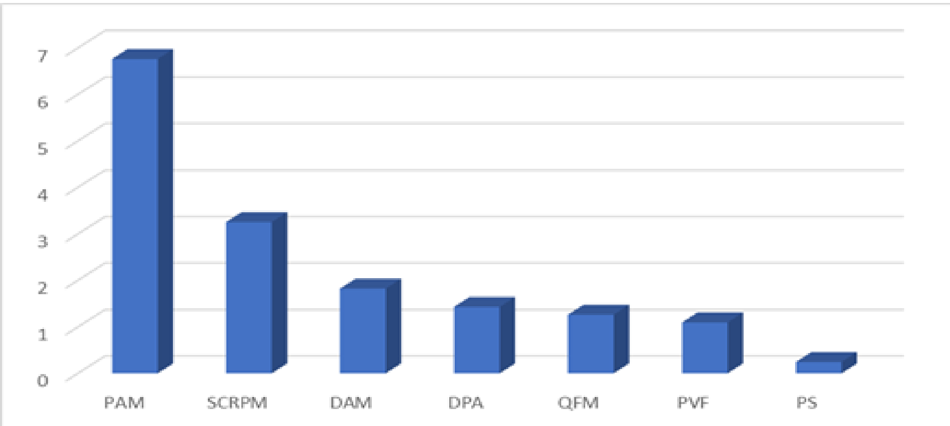

Figure 4. Comparison of suitability scores of various Lean tools [4]

After identifying the main wastes through Value Stream Mapping (VSM) and the waste questionnaire, the most significant waste priorities were determined to be Waiting and Overprocessing, providing a clear picture of the types of waste and their impact on the receiving process in the warehouse. The next step is Root Cause Analysis (RCA) using a fishbone diagram, applied to identify the root causes of these two primary wastes[18].

The identification of root causes was carried out through direct interviews with workers and field observations. The fishbone diagram focused on the two main types of waste, Waiting and Overprocessing, to systematically illustrate the factors causing problems in the receiving process. This analysis aims to enable the company to implement operational improvements in the warehouse, particularly in the receiving process, so that the 3-day lead time KPI target with 100% achievement can be met.

The causes of Waiting/Delay waste are categorized into five main aspects: Material, Man, Method, and Machine. The findings

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indicate that the primary causes of Waiting waste arise from several factors. In terms of Material, the limited availability of forklifts being used simultaneously across multiple processes caused queuing. Regarding Man, the lack of operator competence in handling equipment and the limited workforce slowed down the process. From the Method perspective, calculations were still performed manually, resulting in inefficiency. Meanwhile, in terms of Machine, issues with scanning devices and the internet network caused delays in the Good Receipt (GR) process. The following is a fishbone diagram illustrating the root causes of Waiting/Delay waste occurring in the receiving process at the warehouse of Oil & Gas Logistics Co.

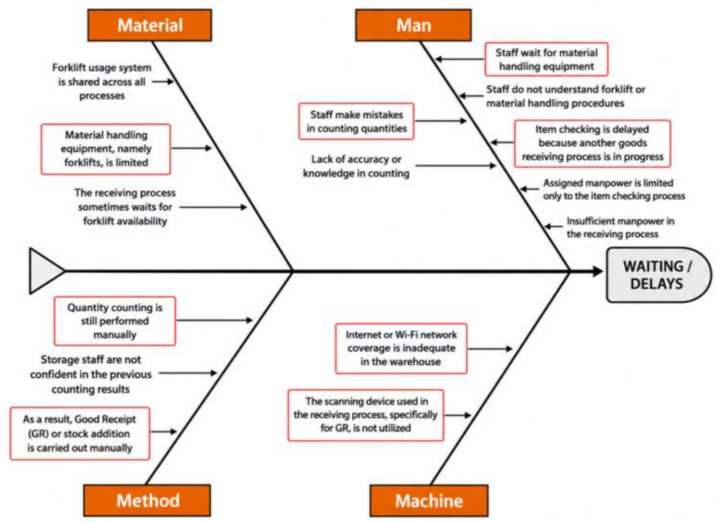

Figure 5 . Fishbone Waiting Delays [5]

From the fishbone diagram above, Overprocessing waste identifies the factors causing excessive processes in the receiving activities at the warehouse of Oil & Gas Logistics Co. The main causes are grouped into several categories, including Material, Man, Method, and Machine. From the Material perspective, discrepancies or damage in the received materials can lead to additional inspection and handling processes that are unnecessary. In terms of Man, the lack of training and understanding of effective procedures by the personnel results in unnecessary steps in the receiving process.

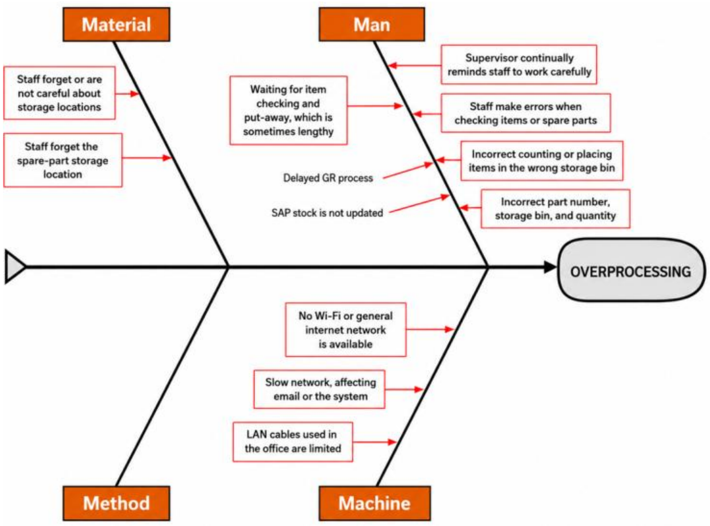

Figure 6. Fishbond over processing [6]

The Method used still involves manual and repetitive processes, which prolongs processing time and increases the risk of errors. Inadequate Machines, such as slow IT systems or suboptimal scanning devices, also contribute to making the processing more complex and time-consuming

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than necessary.[11] This analysis shows that overprocessing is caused by factors related to Man, Method, Material, and Machine. Identifying these root causes enables the company to eliminate unnecessary processes and improve operational efficiency.

After identifying the root causes of waste using the fishbone diagram, the next step is to validate and prioritize the types of waste based on the weights and scores obtained from the VALSAT matrix. This matrix provides a quantitative overview of the severity and frequency of each type of waste, enabling the determination of the most effective focus areas for improvement.

3.3. Process Activity Mapping (PAM)

Based on the VALSAT matrix calculation, Process Activity Mapping (PAM) is used to analyze and evaluate the receiving process. All activities are classified into three categories: Value Added (VA), Necessary but Non-Value Added (NNVA), and Non-Value Added (NVA). A summary of the time proportion in the current state is presented to illustrate the process efficiency level as well as potential waste before improvements are implemented.

Table 2. Current State PAM Recapitulation [3]

Activity	Quantity	Time (Minutes)	Output	%	VA	NNVA	NVA
O	16	653.14	0.319	31.93%	533.07	2.67	32.75
T	12	191.68	0.094	9.37%	183.15	7.93	1.48
I	11	636.58	0.311	31.12%	429.14	99.19	108.25
S	4	323.13	0.158	15.80%	205.31	0.00	0.00
D	16	240.95	0.118	11.78%	282.28	42.26	34.23
Total	59	2045.48	1.000	100.00%	1632.95	152.05	176.71

Table 3 presents a recapitulation of 59 activities across five process groups: Operation (O), Transportation (T), Inspection (I), Storage (S), and Delay (D). Out of a total time of 2,045.48 minutes, Value-Added (VA) activities account for 1,632.95 minutes (79.85%), Non-Value-Added but Necessary (NNVA) activities for 152.05 minutes (7.43%), and Non-Value-Added (NVA) activities for 176.71 minutes (8.64%), indicating opportunities for efficiency improvement through the reduction of NNVA and NVA activities. After the main wastes were identified using a fishbone diagram and validated with VALSAT, all receiving activities were analyzed using Process Activity Mapping (PAM). Each activity was categorized as VA, NNVA, or NVA to assess the efficiency of the current process and to serve as a basis for designing the Future State Mapping (FSM) and determining appropriate improvement actions. The proportion of Non-Value-Added (NVA) activities at 8.64% indicates significant improvement opportunities, particularly in delay and inspection activities that contribute to the total lead time.

3.4. Comparison of Current and Future State Mapping

The comparison shows that the lead time decreased from 1,173.78 minutes to 1,018.50 minutes, or by 155.28 minutes (13.23%), indicating that waste elimination has a significant impact on process efficiency. This reduction is mainly influenced by the decrease in waiting and overprocessing activities, which previously dominated the process.

In the FSM, lead time is reduced through waste elimination and process flow improvements; VA increases, NNVA is minimized, and NVA is reduced through inspection optimization, workflow rearrangement, and waiting time reduction. This analysis serves as a foundation for continuous transformation, improving efficiency, reducing lead time, and supporting the achievement of strategic objectives. A quantitative comparison of VA, NNVA, NVA, and lead time is presented in Table 4, while the efficiency percentages are shown in Table 5.

Table 3. Comparison of Current and Future State Mapping [4]

Activity Category	Current State (menit)	Future State (menit)
VA	885.74	840.88
NNVA	145.56	144.87

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NVA	142.48	32.75
Lead Time	1173.78	1018.50

Table 4. Current vs. Future Results [5]

Activity	%	Activity	%	Efisiensi (%)
VA	75.46%	VA	82.56%	7.10%
NNVA	12.40%	NNVA	14.22%	1.82%
NVA	12.14%	NVA	3.22%	8.92%

Based on performance indicators, the implementation of Lean Service in the receiving process at the Oil & Gas Logistics Co. warehouse shows significant improvement. Lead time was successfully reduced from 1,173.78 minutes to 1,018.50 minutes, or by 155.28 minutes per cycle, bringing receiving performance closer to the KPI targets.

The proportion of Non-Value-Added (NVA) activities decreased from 12.14% to 3.22%, while Value-Added (VA) activities increased from 75.46% to 82.56%, indicating a more efficient process flow (value stream). From a financial perspective, this reduction in lead time results in operational savings of approximately IDR 128,706 per cycle, demonstrating that efficiency improvements also provide tangible economic benefits for the company.

3.5. Lean Improvement Results and Process Efficiency Analysis

Based on the questionnaire analysis using the Seven Waste principle, the most dominant wastes in the receiving process at the Oil & Gas Logistics Co. warehouse are waiting/delays (21%) and overprocessing (19%). This consistency is also reflected in the results of the VSM and VALSAT analyses, which show that these two types of waste contribute most significantly to the process lead time. These results indicate that the Lean Service approach not only reduces waste but also systematically improves the efficiency of the value stream. This analysis is further supported by a fishbone diagram, which identifies root causes related to human factors (lack of training), manual work methods, and limitations in tools and facilities. Value Stream Analysis Tools (VALSAT) were used to determine improvement approaches, and Process Activity Mapping (PAM) was selected as the most relevant lean tool with an effectiveness score of 6%. Current State Mapping (CSM) showed a total receiving process time of 1,173.78 minutes (19.56 hours).

After implementing lean improvements, Future State Mapping (FSM) recorded a reduced lead time of 1,018.50 minutes (16.97 hours), achieving an efficiency gain of 155.28 minutes (2.59 hours). Non-Value-Added (NVA) activities decreased from 142.48 minutes to 32.75 minutes, while Value-Added (VA) activities slightly decreased from 885.74 minutes to 840.88 minutes due to process simplification, and Necessary Non-Value-Added (NNVA) activities remained relatively stable.

Lean cost analysis integrating VSM, VALSAT, and Root Cause Analysis (RCA) demonstrates that reducing NVA activities and improving process flow efficiency not only lowers operational lead time but also provides direct financial benefits. It also serves as a quantitative basis for prioritizing improvements, particularly targeting the most significant wastes waiting and overprocessing.

3.6. Implementation Cost Analysis

3.6.1. Identification of Waste and Potential Savings

Based on the analysis using Value Stream Mapping (VSM), Value-Added vs. Non-Value-Added Analysis (VALSAT), and Root Cause Analysis (RCA), the two primary types of waste identified in the receiving process are waiting and overprocessing. These wastes contribute the most to the total process lead time, making them the top priorities for improvement initiatives. The Process Activity Mapping (PAM) results indicate that the initial Non-Value-Added (NVA) time of 142.48 minutes can be reduced to 32.75 minutes following the implementation of Lean Service-based improvements. This reduction significantly impacts the total lead time, decreasing from 1,173.78 minutes to 1,018.50 minutes per batch, representing a reduction of 155.28 minutes. Further analysis of this data highlights the potential for time and cost savings at each sub-activity level. By eliminating dominant waste, the process flow becomes more streamlined and efficient. Thus, the Lean Service approach is proven to enhance operational efficiency while providing a solid quantitative

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basis for decision-making in prioritizing process improvements.[20]

3.6.2. Cost Assumptions & Savings Calculation

The estimated labor cost for operators is Rp 50,000 per hour, equivalent to Rp 833 per minute, while equipment and overhead costs are estimated at approximately Rp 200,000 per shift, or Rp 8 per minute. Therefore, the total operational cost is Rp 841 per minute. The detailed cost savings resulting from waste elimination in the receiving process are presented in the table below:

Table 5. Cost savings from Waste elimination [6]

Waste Category	Time Reduction (minute)	Cost per Minute (Rp)	Savings per Batch (Rp)
Waiting	80	841	67.280
Overprocessing	29,73	841	25.003
Total	109,73	-	92.283

Table 6. Lean Implementation Cost [7]

Implementation Category	Cost (IDR)	Description
HR Training	5.000.000	Lean Workshop & Receiving SOP Development
Sistem/IT	15.000.000	Scanner, software, and network infrastructure improvements
Documentation & Standardization	3.000.000	SOPs, manuals, and standardized procedures
Layout & Transportation	2.000.000	Reconfiguration of material flow and forklift routing
Total	25.000.000	-

3.6.3.ROI and Payback Period

The monthly savings were calculated based on the assumption of 100 batches per month. The reduction in lead time and Non-Value-Added (NVA) activities generates direct operational cost savings per batch, which can be aggregated to estimate monthly and annual savings. These savings were then used to calculate the Return on Investment (ROI) and payback period for the implementation of Lean Service improvements.

The monthly savings were calculated using the following formula:

$$MS = CS_b \times N_b \quad (1)$$

where MS is monthly savings, CS_b is cost saving per batch, and N_b is the number of batches per month.

$$MS = 92{,}283 \times 100 \quad (2)$$

$MS = Rp9{,}228{,}300$ per month

The annual savings were calculated using the following formula:

$$AS = MS \times 12$$

where AS is annual savings and MS is monthly savings.

$$AS = Rp9{,}228{,}300 \times 12$$

$AS = Rp110{,}739{,}600$ per year

Return on Investment (ROI) was calculated using the following formula:

$$ROI(\%) = \frac{AS-IC}{IC} \times 100\% \quad (3)$$

where AS is annual savings and IC is investment costs.

$$ROI(\%) = \frac{Rp110{,}739{,}600 - Rp25{,}000{,}000}{Rp25{,}000{,}000} \times 100\%$$

$$ROI(\%) = \frac{Rp85{,}739{,}600}{Rp25{,}000{,}000} \times 100\%$$

$$ROI(\%) = 343\%$$

The payback period was calculated using the following formula:

$$PP = \frac{IC}{MS} \quad (4)$$

where PP is the payback period, IC is investment cost, and MS is monthly savings.

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$$PP = \frac{Rp25{,}000{,}000}{Rp9{,}228{,}300}$$

$$PP = 2.7 \text{ months}$$

This analysis assumes a stable throughput of 100 batches per month. Labor and overhead costs were calculated on a per-minute basis to enable an accurate evaluation of time efficiency. Cost savings were assumed to be directly proportional to the reduction in Non-Value-Added (NVA) activities, with no changes to fixed costs. The ROI value of 343% indicates that every Rp1 invested generates approximately Rp3.43 in net return. In addition, the payback period of 2.7 months indicates that the initial investment can be recovered in a relatively short period. These findings strengthen the business case for implementing Lean Service in the warehouse operations of Oil & Gas Logistics Co. and provide a clear quantitative basis for management in prioritizing process improvement initiatives.

4. Discussion

This study demonstrates that integrating Lean Service, Value Stream Mapping (VSM), and Value Stream Analysis Tools (VALSAT) effectively improves the efficiency of the receiving process, a critical inbound activity in oil and gas logistics warehousing. As the starting point of material flow, these enhancements generate systemic impacts on warehouse performance, including reduced lead time, increased Value-Added (VA) proportion, and decreased Non-Value-Added (NVA) activities. The findings indicate that prioritizing inbound process enhancements is a strategic approach to enhance logistics system efficiency, as receiving governs subsequent material and information flows.

Conceptually, this combined approach is well-suited for complex and highly regulated oil and gas logistics environments. The prevalence of waste in waiting and overprocessing reflects a lack of synchronization between physical and information flows, which can be addressed through targeted VALSAT application, delivering structural improvements and economic benefits with relatively low investment while providing a quantitative basis for prioritizing initiatives.

Despite several limitations, including being conducted in a single warehouse, reliance on observations and worker perceptions, and assumptions of stable batch volume and linear cost savings, the framework demonstrates strong transferability potential. It can be adapted to other logistics operations such as fuel distribution, chemical logistics, and broader oil and gas supply chains, with adjustments to activity characteristics, capacity, and regulatory requirements. Integration with digital technologies like Warehouse Management Systems (WMS), IoT sensors, and real-time analytics can further enhance workflows, supporting faster, more accurate, and sustainable operations. Overall, the findings provide practical recommendations for the case study warehouse and present a conceptual framework applicable to the wider oil and gas logistics sector.

5. Conclusions

Analysis based on the Seven Waste principles revealed that the main sources of waste were waiting/delays (21%) and overprocessing (19%), with Process Activity Mapping (PAM), guided by VALSAT analysis, was identified as the most effective improvement tool. Current State Mapping showed a total lead time of 1,173.78 minutes (19.56 hours), which was reduced to 1,018.50 minutes (16.97 hours) after implementing Lean-based improvements, resulting in a reduction of 155.28 minutes per cycle. Non-Value Added (NVA) activities were significantly reduced from 142.48 minutes to 32.75 minutes, while Value Added (VA) remained high, and Necessary Non-Value Added (NNVA) remained stable, in line with Lean principles to increase the value stream and eliminate non-value-added activities. Assuming a labor cost of Rp 50,000/hour, this lead time reduction corresponds to cost savings of approximately Rp 128,706 per cycle, with a high Return on Investment (ROI), while also supporting the achievement of warehouse KPIs. These findings indicate that the implementation of Lean not only improves operational efficiency and accelerates the receiving process, but also provides tangible economic benefits, strengthens KPI achievement, and forms the basis for sustainable warehouse transformation.

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