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Quality Analysis of Outbound Container Stuffing using the Six Sigma Method in a Logistic Shipping Company in Surabaya

Devina Puspita Sari[1], Darien Morieno[2], Alfred Bawole[3]

[123]Teknik Kimia Street, ITS Campus Sukolio

devina.puspita@ppns.ac.id, darienmorieno@student.ppns.ac.id, alfredbawole@ppns.ac.id

Abstract. In the current era of globalization, the role of trade as a driver of a country's economic growth is increasingly significant (Hasoloan, 2013). Good logistics movement is the key to equitable economic development. This study aims to analyze the quality of container stuffing outbound flows in a logistics shipping company in Surabaya using the Six Sigma DMAIC (Define, Measure, Analyze, Improve, Control) method. The main problem identified was operational delays due to the scarcity of empty containers at container yards, which occurred 130 times in the 4th quarter of 2023. The analysis using the Six Sigma method showed a DPMO value of 477,900 and a sigma value of 1.56, which indicated an inefficiency in operations. The DMAIC approach proposes improvement solutions to increase container availability and optimize trucking operations, thereby increasing On-Time Performance (OTP) from 88% to 90%. Implementing these improvements is expected to increase productivity and customer satisfaction and reduce operational costs due to delays.

Keywords: Six Sigma DMAIC, Container Logistics Efficiency, On-Time Performance (OTP) Improvement.

1. Introduction

In the current era of globalization, the role of trade as one of the driving forces of a country's economic growth is increasing (Hasoloan, 2013). Shipping companies, especially the trucking division as inland service actors, play an important role in the logistics ecosystem that supports the flow of goods and commodities traded. A logistics shipping company is an organization that specifically manages and coordinates logistics operations in the supply chain with a primary focus on aspects of marine transportation (Fachrizal, 2020).

According to Frazelle (2002), about 40% of the total expenditure of logistics shipping company is land transportation costs. Therefore, not a few companies use third-party logistics services to help carry out dooring activities in order to achieve OTP with the aim of reducing costs and eliminating waste processes in operations.

In carrying out their operations on land, logistics shipping company rely heavily on reliable land transportation fleets (Muhammad, 2023). This means that the operational success of logistics shipping company is highly dependent on the reliability of a structured and efficient land transportation system. This land freight fleet has an important role in transporting cargo from ports or container container yards to its final destination as well as in supporting various aspects of logistics and distribution.

Expectations for smooth logistics flows are increasing in line with the growth of trade volume. Therefore, logistics shipping company in Surabaya need to improve the quality of container stuffing outbound flows using the Six Sigma DMAIC method (Define, Measure, Analyze, Improve, Control). This study aims to analyze the quality of the current outbound stuffing containers at a logistics shipping company in Surabaya, identify the factors causing operational inconsistencies, and formulate improvement solutions that can improve operational performance and customer satisfaction.

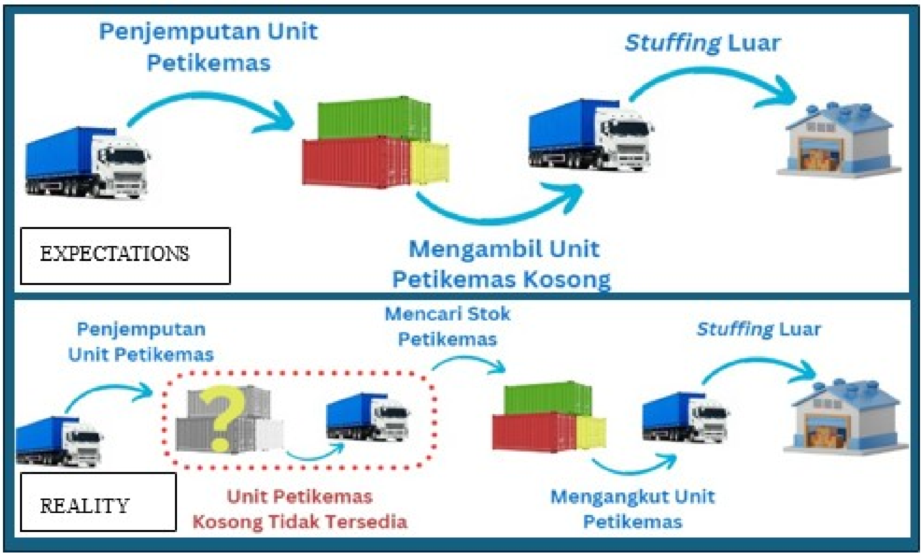

Fig. 1. Operational Flow of Dooring Outbound Stuffing

By applying the Six Sigma method, it is hoped that the company can identify and reduce defects in operational processes, improve efficiency, and achieve targets On-Time Performance (OTP). The implementation of this improvement is expected to increase productivity, customer satisfaction, and reduce operational costs due to delays.

2. Research Methods

The method applied in this study uses a quantitative approach. Data collection was carried out through interviews and documentation studies. The analysis technique used is Six Sigma with the concept of DMAIC. Six Sigma is a disciplined, data-driven approach to reducing or eliminating errors in all service processes. Six Sigma aims to reduce or eliminate errors in the service process. DMAIC is a process that focuses on measuring to improve quality to achieve Six Sigma targets.

The Six Sigma method is designed using DMAIC, which stands for define, measure, analyze, improve, and control. Each stage in D-M-A-I-C has a different purpose and device. The following are the steps of data analysis in this study:

1. Define

The define stage is the first step to identify problems in the company. This step aims to find the variables that cause delays in the research object. Define is carried out by creating a project charter table, mapping the process or operational flow of external stuffing using SIPOC (Supplier Input Process Output Customer) diagrams and Pareto diagrams, as well as determining critical to quality.

a. SIPOC, SIPOC Analysis is used to present a glimpse of the workflow starting from suppliers, inputs, processes, outputs, and customers.
b. Critical to Quality (CTQ). The steps in this CTQ are:
   a. Calculating Critical to Quality (CTQ). At this stage, it is to determine the criteria that cause or have the potential to cause failure or disability.
   b. Establishing Critical to Quality (CTQ). At this stage of CTQ, the most frequent problems are determined.

In the calculation of CTQ, there is an equation that can be used as follows:

$$Percentage(\%) = \frac{Number\ of\ Units}{Number\ of\ Frequency} \times 100 \quad (1)$$

c. Pareto Diagram. The Pareto diagram aims to clarify the most important or the most important of several factors that exist. Thus, the Pareto diagram is used to map the biggest problems based on the results of CTQ analysis.

2. Measure

This stage focuses on understanding the performance of the process chosen for improvement. This stage consists of several stages in it, namely:

a. DPMO calculation and Sigma capabilities. The calculation of the DPMO value is carried out in the following way:

$$DPO = \frac{Number\ of\ Defects}{Number\ of\ Oppotunities\ for\ Defect} \quad (2)$$

b. Control Map. A control map is a technique to control processes on a production line and estimate the parameters of that process. Control charts are used to evaluate whether a process is under control or not, one of which is by using a control map P. Thus, it can be known whether the defective product is still within the specified limits or not. In determining the Lower Control Limit and Upper Control Limit, the following equation is used:

$$p\ October = \frac{Late\ caused\ by\ shortage\ Containers}{Total\ Late\ Order} \quad (3)$$

3. Analyze

The analyze stage aims to identify the root cause of the problem selected in the previous analysis.This stage uses the fishbone technique to find the cause of the damage. Fishbone diagrams can also be used to analyze the causes of damage to shipments.

4. Improve

The improvement stage produces a resolution to the phenomenon that occurs, as the output of a cause-and-effect analysis on the root of the problem. In this study, the improvement stage uses the 5W+1Hmethod to collect, compile, and analyze information comprehensively, as well as why-why analysis to ensure that the proposed solution really addresses the root cause, not just the symptoms. The 5W+1H method is formed from six basic questions, namely:

a. What : What happened?
b. Who : Who is involved?
c. Where : Where did the incident take place?
d. When : When did the incident take place?
e. Why : Why did the incident happen?
f. How : How did the incident happen?

As for the Why-Why analysis, it will require a series of questions and answers that will focus on the root cause of the phenomenon itself, the Why-Why analysis can be presented using the following diagrams:

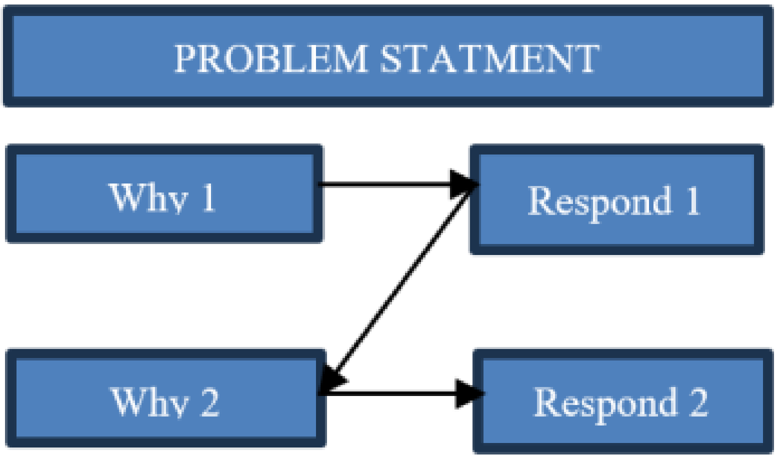

Fig. 2. Why-Why Analysis

5. Control

The control stage is the final phase in the Six Sigma DMAIC methodology. Once the fix is implemented in the improved stage, the control stage focuses on maintaining the improved performance and preventing setbacks to the initial problem. The goal of this stage is to ensure process stability, prevent defects and failures, standardize, and continuous improvement.

3. Result and Discussion

Based on the data collected, various processing and analysis were carried out. The following are the results and discussion of the data processing:

3.1. Define
a. SIPOC

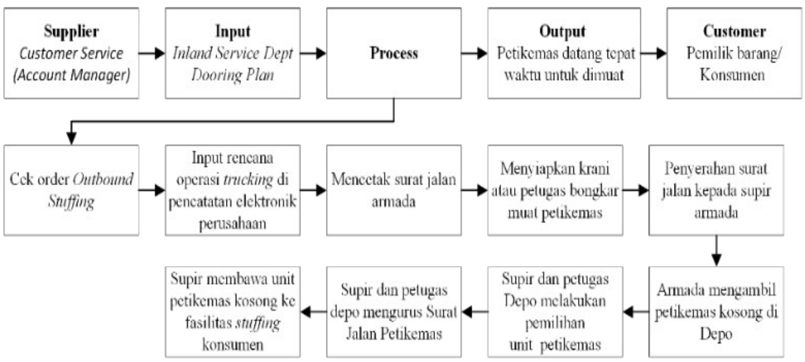

Fig. 3. SIPOC Outbound Stuffing Diagram

Based on Figure 3, the outbound stuffing process can be seen. The expected output of the process is punctuality of delivery. However, in its implementation, there are often obstacles, including delays in the outbound stuffing schedule. The following is data on schedule delays and their causes at logistics shipping company in Surabaya:

Table 1. Outbound Stuffing Delays

Months	Total Orde r	Total Order Late	Short age Container	Accessibility Issues	Human Error s	Fleets Issues	Custo mers Issues	System Defect	OTP
October	787	124	78	10	13	14	6	3	84%
November	747	71	30	8	11	15	3	4	91%
December	753	77	22	21	9	17	7	1	89%
Total	2287	272	130	39	33	46	16	8	-

b. CTQ

Calculating Critical to Quality (CTQ) Based on Table 1 of Outbound Stuffing Delay Events, the cumulative percentage for each type of delay is calculated by equation 2.1 as follows:

- Delays due to Container Shortage

$$Percentage\,\% = \frac{130}{272} \times 100 = 47.80\,\% \tag{4}$$

- Delays due to Accessibility Issues

$$Percentage\,\% = \frac{39}{272} \times 100 = 14.33\,\% \tag{5}$$

- Delays due to Human Error

$$Percentage\,\% = \frac{33}{272} \times 100 = 12.13\,\% \tag{6}$$

- Delays due to Fleets Issues

$$Percentage\,\% = \frac{46}{272} \times 100 = 16.91\,\% \tag{7}$$

- Delays due to Customer Issues

$$Percentage\,\% = \frac{16}{272} \times 100 = 5.88\,\% \tag{8}$$

- Delays due to system problems

$$Percentage\,\% = \frac{8}{272} \times 100 = 2.95\,\% \tag{9}$$

Table 2. Critical to Quality Percentage

No	Problem Identification	Frequency	Frequency Accumulation	Total Percentage	Accumulation Percentage
1	Shortage Container	130	130	47.80%	47.80%

2	Accesibility Issues	39	169	14.33%	62.13%
3	Human Errors	33	202	12.13%	74.26%
4	Fleet's Issues	46	248	16.91%	91.17%
5	Customer Issues	16	264	5.88%	97.05%
6	System Down	8	272	2.95%	100%

c. Pareto Diagram Based on CTQ

Based on the Pareto Diagram in Figure 4, the distribution of the frequency of problems due to various factors is as follows: 47.79% (Shortage Container), 16.91% (Fleet's Issues), 14.34% (Accessibility Issues), 12.13% (Human Errors), 5.88% (Customer Issues), and 2.94% (System Defects). Thus, the problem that will be analyzed at the Measure stage is the Shortage Container factor, which has an incidence frequency of 47.79% and affects the smooth flow of outbound stuffing operations in logistics shipping company in Surabaya.

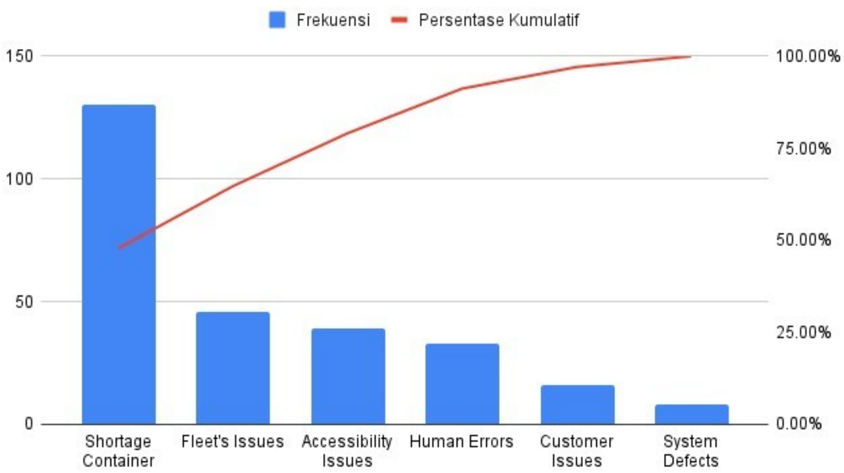

Fig. 4. Pareto Diagram

2. Measure

a. DPMO Calculations and Sigma Capabilities

At the Define stage, bottlenecks in outbound stuffing operations were identified as container shortages with 130 incidents out of a total of 272 delays. This data will be analyzed using the Defect per Million Opportunities (DPMO) value to determine defects per one million opportunities.

- Defect Per Million Opportunities

$$DPO = \frac{130}{272 \times 1} = 0{,}4779 \qquad (10)$$

$$DPMO = 0{,}4779 \times 1.000.000 \qquad (11)$$

$$¿ 477.900\ occurrences\ per\ 1\ million\ chances$$

Next, the search for sigma value values by calculation using Microsoft Excel software.

$$¿\ NORMISINV\ ¿ \qquad (12)$$

$$¿\ NORMISIV\ ¿$$

$$¿1.555.425=1.56\,Sigma\,Value$$

Acquired degree of defect or Defects Per Million Opportunities (DPMO) is around 477,900. This shows that out of everyone million occasions, there are 477,900 delay events, which reflects the performance of the process at the sigma level of 1.56, which means the delay factor due to the existence of a report Shortage Container is highly rated.

b. Control Map

After obtaining the CTQ (Critical to Quality) value for the delay problem due to container shortage, the data will be analyzed statistically to determine whether the cause of the delay is still under control or has exceeded the control limit. The calculation of the percentage of Month, UCL, and LCL can be seen in the following equation.

- Percentage per Month

$$p\,October=\frac{78}{124}=0,629 \quad (13)$$

$$p\,November=\frac{30}{71}=0,4225 \quad (14)$$

$$p\,December=\frac{22}{77}=0,3050 \quad (15)$$

- Average Delay Percentage (as the midline on the control chart (CL)

$$CL\,(Control\,line)=\frac{130}{272}=0,4779 \quad (16)$$

- Determination of Upper Control Limit and Lower Control Limit

$$UCL=0,4779+3\frac{\sqrt{0,4779(1-0,4779)}}{272} \quad (17)$$

$$¿0.4834$$

$$LCL=0,4779+\frac{\sqrt{0,4779(1-0,4779)}}{272} \quad (18)$$

$$¿0.4723$$

Based on the identification of the value of each control limit, the following table is made:

Table 3. Calculation of P Shortage Container Control Limit

Month	Number of Delays	Shortage Container	p	CL	UCL	LCL
October	124	78	0,6290	0,4779	0,4834	0,4723
November	71	30	0,4225	0,4779	0,4834	0,4723
December	77	22	0,3050	0,4779	0,4834	0,4723

After the table is created, the data is then arranged into a control map diagram as follows:

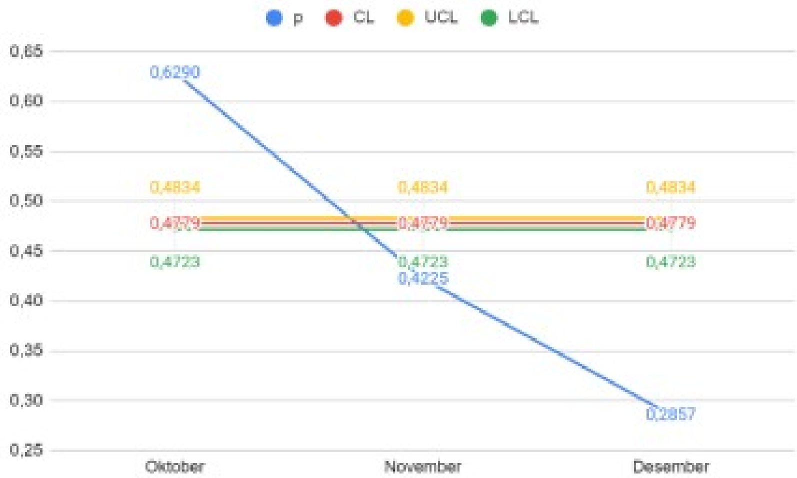

Fig. 5. Control Limit Diagram

Based on the analysis of the control map diagram, it is known that the delays caused by the shortage of containers in the 4th quarter of 2023 are not under control. This is evidenced by the absence of a single month where the container shortage factor is within the control limit (UCL and LCL).

3. Analyze

The Analyze stage was carried out using the Ishikawa Diagram method or also known as Fish Bone Analysis, with the aim of finding out the core problem or root cause of the shortage of containers at the Container Yard.

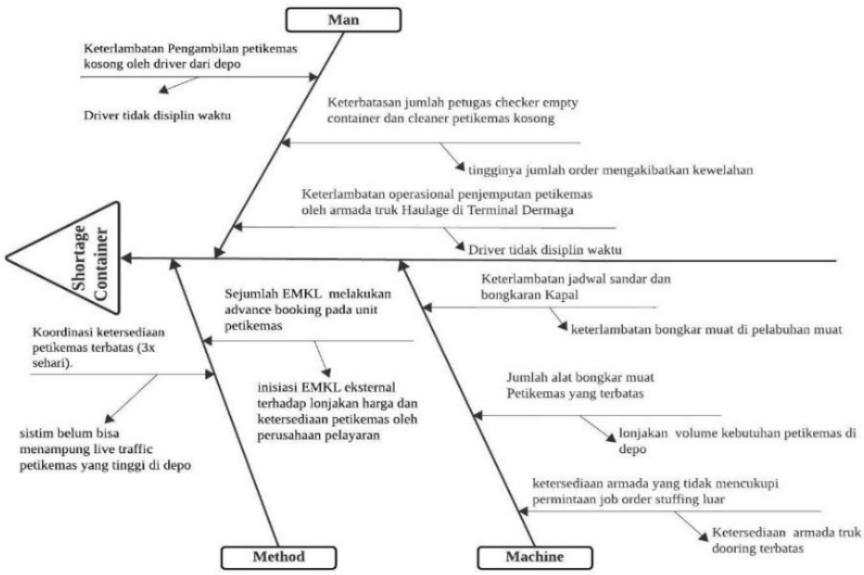

Fig. 6. Ishikawa Diagram

Based on the Ishikawa diagram, each element is grouped into a table that explains the identified root causes and the impacts that occur.

Table 4. Ishikawa Analysis of Container Shortage Diagram

Causative Factors	Root of Problem	Impact
Man	Delay Picking up empty containers by driver from container yard	The available containers will be given to other consumers who come first so the driver has to pick up the available units at other container yards
	Limited number of empty container checkers and empty container cleaners at the container yard	Slowing down the process of picking empty containers to be taken to consumer facilities for oubtound stuffing
	Operational delay in picking up containers by Haulage's fleet of trucks at the Pier Terminal	The company's containers will be transported by the company's trucks and maintained in the port's stack area, incurring additional costs such as stack services and so on.
Machine	Delays in docking and unloading schedules	Causing a shortage of containers at the container yard on a large scale so that the loading and unloading process is significantly disrupted
	Limited number of container loading and unloading tools	Causes a decrease in the efficiency of the turn around time cycle in container units available at the container

		yard
	Limited availability of dooring truck fleet	Delays in dooring schedules due to the availability of private fleets and vendors are not proportional to the number of orders
Method	Policies that allow advance booking of empty container units at container yards	Causing a shortage of empty containers at the container yard, even though the condition of the containers is empty but has been ordered by an external EMKL
	Coordination of limited container availability 3x (Morning at 06.00, Afternoon at 12.00, Afternoon at 18.00)	This causes the planning to pick up empty containers at the container yard to be less accurate, so that there is the potential for miscommunication and waste processing at the container yard by the field team.

4. Improve

Here is the improvement proposals based on root cause identification using Fishbone diagrams and further using the 5W + 1H method.

Table 5. 5W+1H Analysis

Factor	Description	Explanation
Coordination of limited container availalbility 3x (Morning at 06.00, Afternoon at 12.00, Afternoon at 18.00)	What	The update of information on the availability of empty containers at the container yard is limited so that it cannot provide accurate information related to availability to the operational team of the dooring fleet.
	When	At 6 am, 12 noon and 6 pm.
	Where	Field Operator Division
	Why	In order to provide direct information on availability, so as to help the fleet team accurately select the pick-up point for empty containers at the container yard.
	Who	Field Operator Division
	How to solve	By implementing the YMS (Yard Management System) system to facilitate control over the movement and availability of containers at the container yard in real time and can be accessed by stakeholders directly

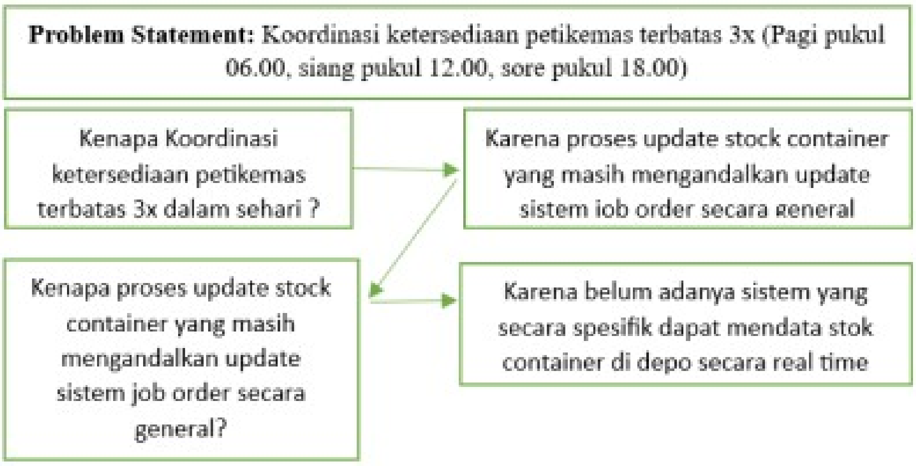

Fig. 7. Why-Why Analysis

Based on the why-why analysis made, the use of a surveillance system such as the Yard Management System is indeed needed to be able to increase visibility of container stock at the container yard and reduce the occurrence of operations that do not have added value such as trucks or fleets that have to move container yards to take MTA (Empty Available) container stock.

5. Control

The control stage shows that there is a decrease in the incidence of delays overall and sub-causes, namely due to shortage of containers at the container yard, overall before and after, as can be seen in Appendices 4 and 6, the average increase in operational optimization based on OTP in the first quarter of 2024 increased by 2%, namely 90%, compared to the fourth quarter of 2023 of 88%.

Table 6. Comparison of OTP 2023 and 2024

Points	%	2023 (Q4)	2024 (Q1)
Company Tolerance Limit	90	88%	90%
Company Achievement Targets	95		
Achievement Description		Below Target	On Target

In January, there were 26 delays, February 25, and March 39, with an average of 30 incidents per month due to stock shortages during the first quarter of 2024. This is 13 incidents lower compared to a total of 43 incidents in the fourth quarter of 2023.

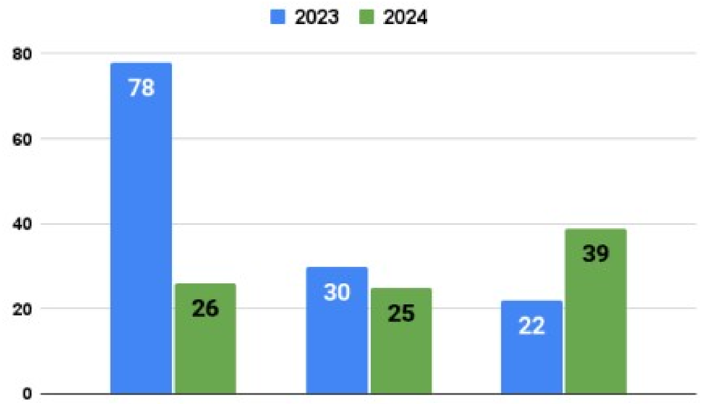

Fig. 8. Comparison of Before and After Improvement

The implementation of routine reporting using YMS (Yard Management System) has been proven to improve the visibility of container stock at the container yard compared to manual recording. For the sustainability of the outdoor dooring stuffing operational optimization program, the solution recommendations that have been provided need to be implemented so that continuous improvement can be achieved.

Thus, research in an effort to improve the reduction of outbound stuffing operational delays in the Surabaya region is said to be operationally successful because it has reached the project target of 90%.

4. Conclusion

Based on the results of the writing on the quality of container stuffing outbound flows using the Six Sigma DMAIC method in logistics shipping company in Surabaya, the following conclusions are obtained:

1. The parties in the outbound stuffing operation are identified by the SIPOC method. Customer Service (Account Manager) acts as a supplier, providing outbound stuffing job orders to the Inland Service Department. The owner of goods or consumers is a corporate account relationship. Input from suppliers is a job plan made by the Inland Service team. The process includes confirming the job order, picking up the stock of MTA containers at the container yard by the driver according to the job order criteria, to sending it to consumer facilities for outbound stuffing. The output is that the container arrives at the loading destination on time.
2. In the application of the DMAIC method, data is needed before improvement as a quantitative background for improvement projects, especially at the Measure stage. This paper uses the DPMO (Defects per Million Opportunities) method and shows that there are 477,900 incidents of delays based on the Shortage Container report, with a sigma value of 1.56. This means that the rate of stuffing delays due to the shortage of containers at the container yard has a high defect rate. Based on the sigma value, the defect level or DPMO is around 477,900, which shows that out of everyone million opportunities, there are 477,900 delay events, reflecting the performance of the process at the sigma level of 1.56.
3. Recommendations for improvement include improved coordination between departments, especially in handling fluctuations in demand and container availability. One of the implementations is to update the availability of MTA containers in real-time through the dashboard using the Yard Management System module for reporting the availability and forecasting of MTA container needs at the container yard. This is done by RFID scanning of the return letter which automatically converts the status of the ex-unloading container to MTA. Other recommendations that are still under consideration include a dashboard for forecasting the needs of haulage and dooring truck fleets, forecasting

ship berthing schedules, and forecasting the needs of field human resources such as cranes and empty checkers at container yards.

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