Reducing Procurement Waiting Time through Lean Six Sigma

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Abstract. A Mass Transportation Manufacturer (MTM) is a pseudonym for the company's name as the subject in this study, faces significant challenges in its procurement process, particularly in acquiring components from foreign suppliers, which often results in prolonged delays. This delay in procurement has a direct impact on product delivery timelines, affecting overall customer satisfaction. To address these issues and optimize MTM's procurement process, this study aims to adopt the DMAIC framework. Primary focus will involve using the Lean Six Sigma method to analyze the procurement process and identify critical areas of wastage. Root cause analysis will be conducted using the 5 Why's method, while the Failure Mode and Effect Analysis will help prioritize high-risk wastage areas for improvement. This study will further employ Quality Function Deployment to align optimal solutions to customer expectations and technical requirements. To determine the best combination of solutions, the Analytical Hierarchy Process will be used. In conclusion, the study's comprehensive approach seeks to enhance the effectiveness and efficiency of MTM's procurement process and reduce delays in product delivery. For future research, incorporating additional information and data on the financial and legal aspects of the recommended solutions could further enrich the study's findings.

Keywords: Procurement Process, Lean Six Sigma, DMAIC, Quality Function Deployment, Analytical Hierarchy Process

1 Introduction

MTM is a mass transportation equipment manufacturing company with a proven track record of catering to both local and global markets. Given its nature, MTM relies on a diverse range of constituent components to fabricate mass transportation means, causing a comprehensive procurement process. Unfortunately, it is not uncommon for this procurement process to become overly time-consuming, leading to significant waiting periods for components. The prolonged waiting time from the initiation of the procurement process until the components' arrival disrupts production schedules, resulting in

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delays in the manufacturing process and, ultimately, delays in delivering the final product to customers.

One thing that causes these problems is the component profile required by MTM in the manufacture of mass transportation equipment currently still has over 50% of components are imported components that are not produced domestically, so it takes quite a long time when viewed from the order stage until the goods are sent by the supplier. Main components, such as propulsion components, engines, generators, wheels, and other components, are imported from various countries outside Indonesia. Its suppliers are also spread across Asia such as China, Japan, and India, then in Europe such as Spain, Germany, Italy, and America. This, of course, needs to be expected by performing an appropriate and appropriate sourcing process to produce a more effective total procurement time.

MTM experienced a significant increase in terms of sales in 2015-2019, namely an average of 30% each year. This increase was because of several things, such as increased capacity and production patterns, government support for domestic orders, and expansion into international markets.

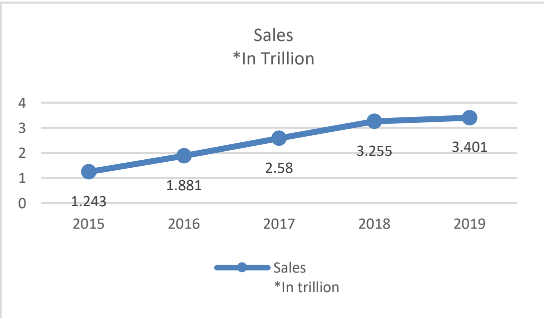


Fig. 1. Graph of Sales Trend of MTM, 2015-2019

However, this increase is also directly proportional to fines caused by delays in prosecuting train units to consumers (Fig 2). This delay is also reflected in the realization of the company's KPI (Key Performance Indicator) in terms of timely delivery of the final product to consumers which has been unsTable in the last 5 years as can be seen in Table 1.1 below.

Table 1. KPI Timely Delivery of Final Products to Customers

Year	%KPI
2017	88.53%
2018	83.34 %
2019	88.65 %
2020	66.75 %

2021	71.50 %

This is also one of the obstacles experienced by MTM if you want to fight in the global market apart from price, quality, and mastery of technology. So this is considered important to be repaired in addition to improving the financial performance of MTM, also to increase competitiveness in the global market.

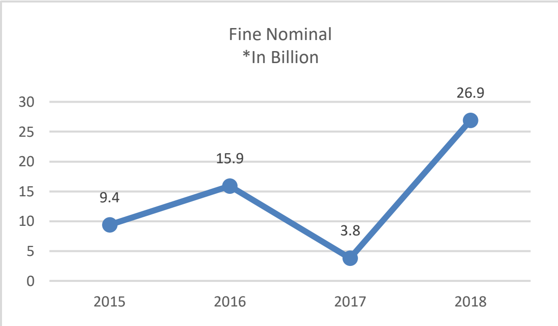


Fig. 2. Profile of Penalties Trends Due to Delay in Product Delivery to Customers, 2015-2018

From the Table and infographic above it can be seen that there are problems with the duration of production carried out by MTM thus causing delays. This is inseparable from the performance of the procurement carried out and is reflected in the value of the company's KPI (Key Performance Indicator) in terms of the Timeliness of Arrival of train materials and components which can be seen in the Table below.

Table 2. KPI On-Time Arrival for Components

Year	%Achieved
2019	62.07 %
2020	20 %
2021	63,1 %
2022	11,92 %

Procurement activity is one of the activities in a series of business processes carried out by MTM is an activity with the longest lead time in a business process that is carried out with a value of approximately 60% -70% of the total time needed to produce train cars, so it is very important for MTM has an effective and efficient procurement process.

2 Literature Review

2.1 Procurement

Procurement is the process of obtaining goods and services in the supply chain. In another definition, procurement is defined as activities related to the acquisition of a product or service. The range of activities can vary widely between organizations to cover all parts of the planning function. Procurement, purchasing, inventory control, traffic, receiving, incoming inspection, and rescue operations [1]

The procurement process will generally be divided into two main parts, namely sourcing and purchasing/ordering. Each part that has stages that must be carried out can fulfill the main goal, namely achieving the service level that has been determined by the company.

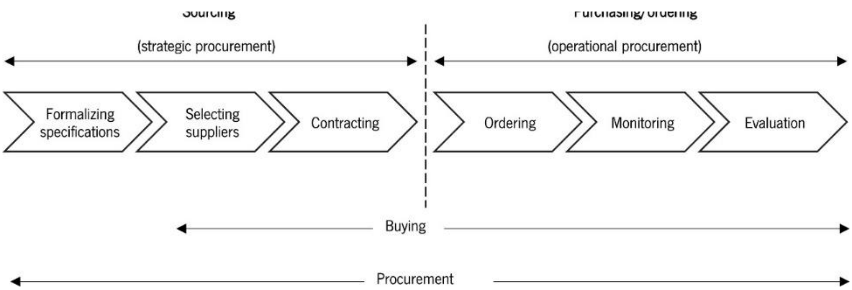


Fig. 3. Procurement Process [1]

2.2 Lean Manufacturing

Lean Manufacturing is the right method for optimizing the performance of a production process because it can call, measure, analyze and provide suggestions for the improvement and development of existing processes to improve the performance of running processes comprehensively. The lean concept itself is reflected in the concept of reducing or eliminating waste that exists in a series of ongoing processes related to fulfilling orders from customers [2].

2.2.1 Waste and Activity Identification

In lean manufacturing, the process should be more effective and efficient, which means we have to minimize the waste or even further eliminate the waste within the process. Lean Manurfacturing initially implemented in manufacturing industry such as automotive industry, textile and other industry that produce goods, but now Lean Manufacturing use is adopted oto other industry such as service providers like Higher Education

Institutions [3], and in this study using this approach to use Lean Manufacturing in procurement process. Before we minimize or eliminate the waste, first we have to identify the activity of the process, and in general, the activities are divided into 3 (three) categories, that are value-added activity (VA), non-value-added activity (NVA), and necessary non-value-added activity (NNVA) [4]. Waste can be interpreted as an activity that has no added value and can sometimes harm a series of production processes that are carried out so companies must be able to minimize or even eliminate waste that occurs in the production process. According to Suhartono (2007), in the Toyota Production System, 8 wastes generally occur in an industrial production process, namely Waiting, Defects, Over-Production, Excess Processing, Transportation, Inventory, Motion, and Non-Utilized Talent [5].

2.3 Quality Function Deployment – House of Quality

Quality Function Deployment or QFD is a product planning and development method that accommodates the needs and desires of customers as a whole and clearly. QFD is also an effective management tool to get the customer expectations and its deployment into the technical responds so we could get the actions or solution that in line with the customer expectation [6]. QFD can also be used to introduce products to management regarding functions, strategies, and plans for products made of course with customer orientation [7].

2.4 Failure Mode and Effect Analysis

Failure Mode and Effect Analysis or FMEA is a stepwise approach to be able to identify all possible failures in a design, production process, or product or service assembly process. In FMEA calculations, several factors that determine the reliability of failure and the impact of risks that may occur are severity, occurrence, and detection [8].

3 METHODS

The research methodology involved the gathering of primary data through questionnaire surveys and secondary data through interviews and brainstorming sessions with experienced senior employees and managers at the company, each having more than a decade of experience within the organization. These interviews and questionnaires aimed to gain comprehensive insights into both the procurement process and waste classification. Additionally, brainstorming sessions were conducted to develop alternative solutions.

Furthermore, the research was carried out using the DMAIC frameworks, encompassing the stages of Define, Measure, Analyze, Improve, and Control. The utilization of these frameworks ensured a well-structured and systematic approach to the research, fostering a more organized and effective investigation..

4 RESULTS AND DISCUSSIONS

4.1 Define Phase

In this stage, interviews and brainstorming are carried out to describe the business process of procurement in the company to understand better the process and make it easier for knowing the problem in the process. After that, a flow chart of the process business is made so there is no step missing and we could see the whole process.

4.2 Measure Phase

In this stage, a series of questionnaires are used to capture the condition of the running state of the process. These questionnaires are also used to know the gap in customer expectations and satisfaction with the process. To find out whether the data can be used or not, several tests were carried out on the data obtained namely Data Adequacy Tests (N>N' with result 20>12,6 which means distribution data for the questionnaire is sufficient), Validity Test (the value of t_{count} for all parameters are greater than t_{tablet} which 1.729) and Reliability Tests (the value of R_{count} is greater than R_{Table} which 0.444).

The questionnaires are used to determine the classification of the activities and to identify the waste that exists in the process. The following is Table 1 showing the results of Critical Waste in the process.

Table 3 Results of Critical Waste

Waste	*Score*	*Weight After Normalization*	*Ranking*
Waiting for the next step (Waiting)	135	0.241	1
Excess Processing (Processing)	125	0.223	2
Transport of documents (Transportation)	91	0.163	3
Errors in documents (Defect)	86	0.154	4
Doing work not requested (Overproduction)	63	0.113	5
Non-used Resource	33	0.059	6
Unnecessary motions (Motion)	19	0.034	7

4.3 Analyze Phase

After the waste is identified, analysis is performed to find the root cause of the waste. In this study, only the top 3 of all waste is analyzed. Root Cause Analysis (RCA) is used to find the root cause of waste for awaiting the next step, Excess Processing, and

Transport of Documents in the business process. The following Table 4 shows the sub-waste and root cause for each waste.

Table 4 Waste and Root Cause

Waste	Sub Waste	Root Cause
Waiting for the next step (Waiting)	Purchase Order issuance process is hampered	Lead time for production of components from suppliers is long
		Components cannot be produced in small quantities
	The Bill of Materials (BoM) is unclear as a basis for purchases	There is no standard component specification yet
		The specifications issued by the customer during the tender are still common
		Update specifications from customers
		The required components are no longer on the market
Excess Processing (Processing)	Issuance of the same document as a pric	Subsidiaries/company affiliates do not yet have the desire for the components of mass transportation equipment
	Repeated technical approval process	Lack of communication and explanation to potential suppliers
		The component you are looking for is no longer on the market
	Preparation of different procurement progress reports with the same source or content	There is no centralized procurement progress reporting system
Transport of documents (Transportation)	Distribution of PO documents physically or not paperless	There is no system that is legally recognized by all related parties that replaces physical contract documents
	Distribution of Master Schedule documents that are still in physical form sent to each relevant division	Not all related divisions have the program needed to open the created master schedule softfile

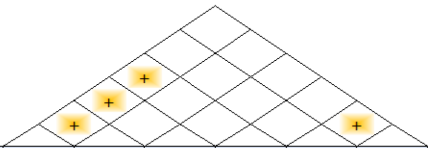
After all the root cause is identified, the method used for assessing the condition of each waste and finding the solutions for each root cause is Failure Mode and Effect Analysis (FMEA). The assessment is conducted by using historical data and experience from the past for each waste. The following Table 5 is the FMEA Table for the highest RPN for each waste.

Table 5 FMEA & RPN Table

Waste	*Potensial Failure*	*Potensial Effect*	S	*Potensial Cause*	O	D	*Control*	RPN	*Recommended Action*	*Actions Taken*
Waiting for the next step (Waiting)	The Bill of Materials (BoM) is unclear as a basis for purchases	It takes a longer time to be able to do the sourcing because the component you are looking for is not a common component	6	There is no standard component specification yet	6	5	Using preliminary BoM to do initial sourcing	180	Make a standardization of the components of mass transportation equipment	Conduct discussions and analyzes to standardize the components of mass transportation equipment
Excess Processing (Processing)	Issuance of the same document as a price quote letter from the company to the subsidiary/affiliate and the subsidiary/affiliate to the supplier	The administrative process is repeated because the child/affiliate carries out the same procurement process flow	6	Subsidiaries/Affiliated companies do not yet have an agency for the components of mass transportation equipment	5	5	Coordination with children/affiliates	150	Proposing that each child/affiliate has an agency for the main components of mass transportation	Identify the required components and potential suppliers for the agency process for subsidiaries/affiliated companies
Transport of documents (Transportation)	Distribution of PO documents physically or not paperless	The next process is waiting for all documents to be physically signed	5	There is no system that is legally recognized by all related parties that replaces physical contract documents	8	3	Recording using document expedition	120	Propose the development of an Online Purchase Order system	Identify the need for system integration with subsidiaries/affiliated companies, report forms and all required information

After determining the priorities for which waste will be impoverished, Quality Function Deployment–House of Quality is used to identify the relationship between customers' requirements and technical requirements. This step is necessary to find the most suitable solution.

Table 6 House of Quality



Column #	1	2	3	4	5	6
Direction of Improvement	◇	▲	▲	◇	▼	▲
Technical Requirements	Regular coordination with suppliers regarding technical discussions	Conduct discussions and analyzes to standardize the components of mass transportation equipment	Identify the required components and potential suppliers for the agency process for subsidiaries/affiliated	Perform routine coordination to maintain relationships with customers	Make a software procurement proposal	Identify the need for system integration with subsidiaries/affiliated companies, report forms and all required information
Issuance of component technical specifications		●●	●	●		
Issuance of Bill of Material (BoM)		●●	⊙	⊙		
Issuance of Purchase Requisition (PR)	O	⊙				⊙
Issuing a Letter of Request for Price of Goods			●			●
Checking the Price Offer Letter			●			●
Submission of technical approval	⊙	●●	●		⊙	⊙
Price Negotiation and Target Delivery Time		⊙	●			
Price Negotiation and Target Delivery Time			⊙			
Monitoring the realization of the procurement process and evaluation of supplier performance						⊙
Max Relationship	4	10	7	7	4	7
Importance Rating	37.777778	213.33333	428.88889	40	26.666667	368.88889
Relative Weight	3%	19%	38%	4%	2%	33%
Weight Chart						

Based on Table 6, the technical requirements with the highest Importance Rating Value are about integrating the system for all subsidiaries and affiliates and the second highest rating is about the standardization of constituent components of mass transportation.

4.4 Improvement Phase

To get the most effective recommended solution, an additional step is required to combine the various suggestions. During this phase, improvement suggestions aimed at reducing or eliminating waste impact are planned through discussions with key personnel within the company. The AHP method is then used to identify the best alternative solutions for the company.

The study proposes an alternative combination that involves creating an integrated platform for the procurement process, monitoring, and evaluation. Standardizing the constituent components of mass transportation and fostering long-term partnerships with component principals are also emphasized.

By implementing these solutions, the procurement process can be optimized, and all identified waste in the study can be eliminated. These combined alternatives have the potential to assist the company in achieving its goal of reducing waiting times for materials.

4.5 Control Phase

In the control phase, SOP for implementation of the suggested solution is made to make sure that the solution is implemented and evaluated successfully. So, the same problem does not reappear in the future. The SOPs should be implemented both in the company and in the subsidiaries and affiliates because the suggested solution is for all parties.

4.6 Additional Discussion

The application of Lean Six Sigma in this study is relatively uncommon. As a result, several adjustments were necessary to tailor the methods and approaches used to address the encountered problems. Notably, the author did not discover any similar studies specifically focused on applying Lean Six Sigma in the procurement process.

However, it is anticipated that this study may serve as a catalyst for encouraging further research in this area and prompt more comprehensive investigations into similar cases. To enhance the research, additional data such as financial information, costs, and legal implications pertaining to the implementation of solutions for companies could be incorporated.

5 CONCLUSIONS

Waste has been identified within the procurement process at MTM, and the three most prominent types of waste are Waiting for the next step (Waiting), Excess Processing (Processing), and Transport of Documents (Transportation). The waste of Waiting for the next step is attributed to two specific activities. Firstly, the Bill of Material remains unclear, which hampers the purchaser's ability to initiate procurement based on these essential documents. Secondly, delays in the purchase order issuance process lead to a setback in component deliveries. Regarding Excess Processing, the waste is generated by redundant activities such as issuing the same documents multiple times in the Request for Quotations process, both from the company to the subsidiary/affiliate and from the latter to their sub-vendors. Additionally, repeating the technical approval process for the same requested components contributes to the waste. Furthermore, preparing different progress reports using the same source or content also adds to the Excess Processing waste. As for the waste related to Transportation of Documents, it arises from the physical distribution of Purchase Orders and Master Schedules to various related divisions. In summary, the procurement process at MTM suffers from waste in the form of Waiting, Excess Processing, and Transportation of Documents, stemming from specific activities that can be optimized and streamlined to enhance efficiency..

The suggested solution involves integrating the processes within the company, its subsidiaries, and affiliates onto a shared platform. Additionally, implementing standardization for the constituent components of mass transportation equipment is proposed. Moreover, there is an emphasis on fostering long-term cooperation between subsidiaries, affiliates, and component principals to secure favorable pricing, lead time, and component availability. By implementing these combined solutions, the company anticipates resolving its current challenges and significantly reducing the waiting time for components, spanning from the inception of the procurement process to the delivery of components at the company's premises.

The attainment of the waste reduction target relies on the commitment of each party involved. With dedicated commitment, the implementation can progress smoothly, leading to continuous process improvement.

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