ENHANCING LOGISTICS SERVICES THROUGH THE APPLICATION OF LEAN SIX SIGMA METHODOLOGY: A CASE STUDY

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ABSTRACT

The study focused on analyzing warehouse operations at MARIO Logistics and Freight Forwarding. The warehouse operations experienced a recurring damage issue. The aim was to address key challenges, notably issues related to damaged bags during warehouse operations. The study used the SIPOC framework, Fishbone diagram, and FMEA to identify the root causes that contribute to process defects. The study recommends several actions to improve the organization such as implementing thorough staff training programs, establishing standardized processes, improving communication and coordination, implementing strong quality control measures, and upgrading technology infrastructure. Developed and applied to real operation in May and June 2023 and maintained to the present. The actions that were implemented resulted in significant improvements. The measures taken successfully eliminated damaged goods in the warehouse, reducing it to 0% which was 0.29% and 0.10% respectively.

***Keywords**: DMAIC, FMEA, logistics, operational efficiency*

บทคัดย่อ

การศึกษานี้มุ่งเน้นไปที่การวิเคราะห์การทำงานในคลังสินค้าที่ บริษัท MARIO Logistics and Freight Forwarding ซึ่งพบปัญหาเรื่องความเสียหายที่เกิดซ้ำๆ ในการทำงานในคลังสินค้า วัตถุประสงค์ คือ การแก้ไขปัญหาหลักที่เกี่ยวข้องกับกระเป๋าเสียหายในขณะทำงานในคลังสินค้า การศึกษาใช้กรอบงาน SIPOC แผนภูมิก้างปลา และ FMEA เพื่อหาสาเหตุหลักในการเกิดปัญหาของกระบวนการ การศึกษานี้แนะนำหลายมาตรการเพื่อปรับปรุงองค์กร เช่น การฝึกอบรมพนักงาน การกำหนดกระบวนการให้เป็นมาตรฐาน การปรับปรุงการสื่อสารและประสานงาน การใช้มาตรการควบคุมคุณภาพอย่างเข้มงวด และการยกระดับโครงสร้างเทคโนโลยี ได้รับการพัฒนาและนำไปใช้ในการทำงานจริงในเดือนพฤษภาคมและมิถุนายน ปี ค.ศ. 2023 และยังคงใช้อยู่จนถึงปัจจุบัน มาตรการที่ได้ดำเนินการส่งผลในการปรับปรุงที่สำคัญ ช่วยลดความเสียหายในคลังสินค้าจากเดิม 0.29% และ 0.10% ลงเป็น 0% ได้สำเร็จ

คำสำคัญ: DMAIC FMEA ลอจิสติกส์ ประสิทธิภาพการทำงาน

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INTRODUCTION

Established in 2016, MARIO Logistics and Freight Forwarding in Yangon, Myanmar quickly rose to prominence as a leading provider of logistics and freight forwarding services. In their brief existence, they have demonstrated dedication to delivering exceptional import/export assistance, customs clearance, and transportation processes to all clients.

Despite its initial success, MARIO Logistics and Freight Forwarding faces significant hurdles in its warehouse operations. One particular challenge the company encounters is addressing the issue of damaged bags. As a consequence, the company has suffered financial losses and its overall logistics process and reputation have been adversely affected.

The objectives of this research were to identify the root causes of damaged goods in a warehouse and to develop practical and sustainable solutions that can improve quality and efficiency of MARIO's logistics process and document management.

The researcher used information from March and April 2023 as a starting point to collect the data. The implementation took place in May and June 2023, and the results were monitored until July 2023. The data validation for the whole project took 5 months from March 2023 until July 2023.

REVIEW OF RELATED LITERATURE

Logistics Documentation Process

Logistics documentation plays a pivotal role in ensuring smooth operations throughout the supply chain. All forms of documentation are included, and they aid in making the data clearer and easier to understand while also making data discovery easier (Attard, Orlandi, Scerri, & Auer, 2015). In addition, effective logistics documentation ensures accurate and timely product movement, facilitates compliance with regulations, and provides traceability across the entire supply chain (Blanchard, 2011). Logistics documentation plays a crucial role throughout the different phases of the project.

Operation Process in Logistics

The ultimate aim of the operational process in logistics is to optimize the movement of goods and services while simultaneously reducing costs and enhancing customer satisfaction (Bowersox, Closs, & Cooper, 2013). Achieving this requires the implementation of different strategies such as just-in-time (JIT) delivery, lean logistics, and agile logistics (Christopher, 2016). In today's fiercely competitive world, organizations strive to enhance their products and processes through continuous improvements (Thomas, Barton, & Chuke-Okafor, 2009).

Lean Six Sigma

Lean Six Sigma (LSS) is a methodology aimed at eliminating unwanted process or activity and variation while following the DMAIC structure. Its goal is to satisfy customers in terms of quality, delivery, and cost (Salah, Rahim, & Carretero, 2010). Singh and Rathi (2019) found that the deployment of LSS has been highly successful in the service industry. Their research emphasizes LSS's effectiveness in enhancing service quality, improving customer satisfaction, and streamlining operations. Numerous studies by Lande, Shristava, and Seth (2016) and Singh and Rathi (2019) confirm that LSS is a practical and established method for achieving outstanding processes across various industries. It proves to be an efficient strategy for driving organizational performance.

DMAIC

The first step in the DMAIC process, known as the Define phase, is crucial in solving problems using the structured methodology of Six Sigma (George, 2003). Its main objectives are to create a well-defined and measurable problem statement, establish the process, and identify customer requirements (Pyzdek & Keller, 2018). In the measure phase, establishing a baseline for process performance, identifying critical inputs are primarily included (Yuan, Zeng, Skibniewski, & Li, 2009) evaluating capability levels, uncovering root causes of problems through data collection, assessing customer satisfaction through surveys and feedback, and obtaining relevant metrics to gain insights into problem causes.

The "Analyze" phase of the DMAIC model in process improvement focuses on understanding and pinpointing the root causes of a problem or inefficient process (Pyzdek & Keller, 2018). This stage involves utilizing various methods and tools such as data analysis, process mapping, cause-and-effect diagrams, statistical analysis, Fishbone Diagrams, 5 whys, and hypothesis testing (Ahmed, Hassan, & Taha, 2004). The Improve phase leverages previous analyses to develop process modifications aimed at enhancing overall performance (Ponsiglione, Ricciardi, Scala, Fiorillo, Sorrentino, Triassi, & Improta, 2021). In the Control phase, various procedures and actions are established to continuously monitor and control important variables within predetermined bounds. Control plans allow for the monitoring and controlling of processes to maintain the gains that have been made (Kumar & Sharma, 2012).

SIPOC

The SIPOC tool, which stands for Suppliers, Inputs, Process Outputs, and Customers, is widely used in Six Sigma to analyze and document business processes (Juran & De Feo, 2010), and breaks down a process into five essential components during review, providing an overall perspective (Sharma, Malik, Gupta, & Jha, 2018). The SIPOC tool serves as a fundamental resource during the Define stage of the DMAIC improvement process (Rother & Shook, 2009). It enables the mapping of processes and identification of crucial stakeholders. Moreover, it helps establish project scope, defined targets, and lays the groundwork for subsequent steps.

Process Mapping

Process mapping allows participants to closely examine every aspect of a process and make informed decisions about specific steps involved (Rummler & Brache, 2012). Process maps depict both workflow and interactions within organizations (Gershon, Rothrock, Hanrahan, Jansky, Harniss, & Riley, 2010). Moreover, they enhance decision-making transparency and aid in identifying redundancies or bottlenecks within and between processes (Harmon, 2013).

Interviews

A crucial instrument in qualitative research, interviews are one of the most efficient primary data collection methods that must be used (Gill, Stewart, Treasure, & Chadwick, 2008). To ensure accurate and reliable results, De Vaus (2013) emphasizes the importance of having clearly defined study objectives, employing suitable sample strategies, and meticulously preparing the questionnaire. Cohen, Manion, and Morrison (2007) emphasize the significance of interviews in exploring meaning production and negotiation within natural settings.

Fishbone diagram

Cause and Effect Diagrams are used to visually represent the contributing causes that impact an outcome or quality feature requiring improvement (Juran & De Feo, 2010). Each major branch corresponds to significant causes or groups of factors directly influencing the result, while minor branches represent more specific contributors (Pande, Neuman, & Cavanagh, 2000). Using cause and effect diagrams has several benefits, one of which is that it makes it easy to understand the relationships between a product's problems and their possible causes (Luca, 2016).

Failure Modes and Effects Analysis (FMEA)

FMEAs play a vital role in process analysis, allowing users to identify potential failures and their impacts. This, in turn, helps prevent failures during the design phase (Stamatis, 2003). FMEA has been a well-established process for enhancing production quality and reducing the severity and frequency of failure (Huang, Xu, Liu, & Song, 2021). It assesses each failure mode by considering severity, occurrence, and detectability as key factors (Kutlu & Ekmekçioglu, 2012). The FMEAs assess the relative importance of failure modes, causes, components, and systems by utilizing the Risk Priority Number (RPN) (Leimeister & Kolios, 2018). Each failure mode undergoes evaluation using three parameters: severity (S), likelihood of occurrence (O), and difficulty of detection (D) (Alizadeh, Damanab, Rasoulzadeh, Moshashaie, & Varmazyar, 2015). The modes of failure with the highest RPN score should be examined first. The risk priority number (RPN) is the result of combining severity, occurrence, and detection (Alizadeh et al., 2015).

RESEARCH METHODOLOGIES

This section includes the research methodology and possible tools to identify the root causes. According to the company, the warehouse operations experienced a recurring damage issue. In March, the defect rate for damaged goods was 0.29%, and 0.10% in April. These errors resulted in a defect rate of 20% for each month. These numbers highlight potential flaws in the handling and storage procedures, which have adverse effects on the company's finances and customer relationships.

Define
During this phase, the main objective is to accurately define and describe the identified issues. One particular concern involves the occurrence of damaged non-dairy creamer packs during transportation from the Myawaddy warehouse to Yangon. This problem specifically been occurred in March and April of 2023, resulting in customer complaints and the need for compensation to be provided.

SIPOC Diagram
In the context of addressing issues related to damaged goods in the warehouse operating process and frequent invoicing problems at Mario Logistics Company, the SIPOC framework, Table 1, is effectively employed. It is essential to acknowledge that operational errors can occur at various stages, leading to disruptions in flow and negatively impacting overall efficiency and accuracy of operation.

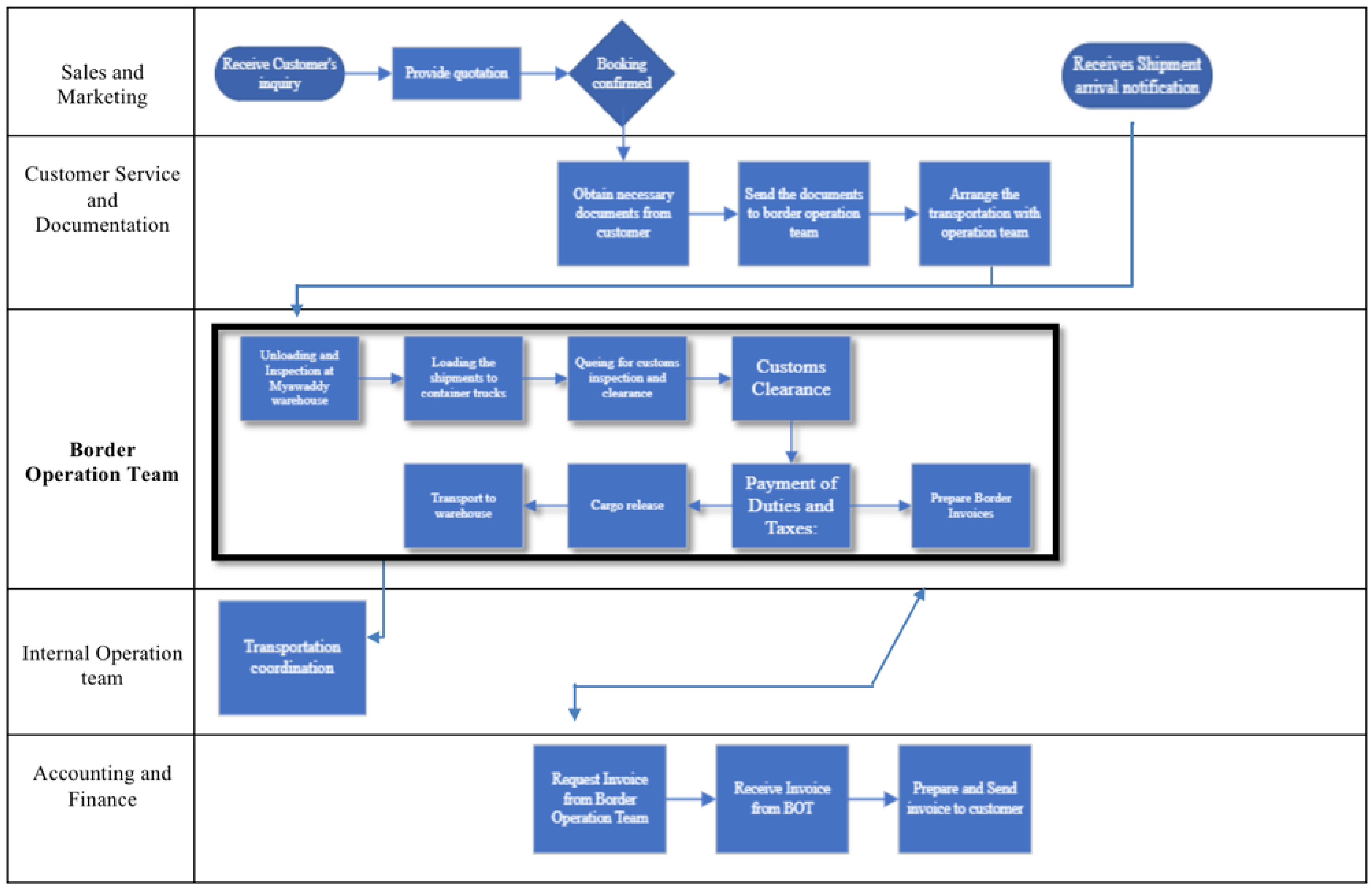
Table 1: Critical Findings on Warehouse Operation Process SIPOC

Stage	**Description**	**Critical Findings**
Supplier	- Businesses responsible for shipping and delivering the merchandise from Mae Sot to the warehouse	To select dependable providers who can deliver cargo securely and on time.
Input	- Cargo, documentations and warehouse facilities	- Cargo should be properly packed and secured. - Complete the necessary documentation in time.
Process	- Arrival of the goods at the warehouse - Customs clearance process	- Proper storage practices should be followed. - Completion of required documents
Output	- The accurate and timely delivery of the cargo	- Cargos in good condition, free from any damages or discrepancies.
Customers	- Warehouse personnel	- Cargo to be delivered on time, in the expected quantity, and in good condition. Any delays, damages, or errors in documentation can impact.

Measure
In measure stage, two key methods were employed to gather information on the warehouse's damaged items.

Data Collection
The first method involved direct observation conducted at the MARIO border warehouse. This included examining transportation processes and maintenance activities. To ensure accuracy and

Figure 1: Process Mapping of Warehouse Operation



minimize bias, a combination of random sampling and predefined observation criteria was employed. The observations provided a firsthand understanding of the logistics operations. After conducting a thorough examination, several areas for improvement were identified in the workflow and process section. The warehouse's operational effectiveness can be enhanced by addressing these key findings through implementing appropriate measures and actions.

Interview

A set of interviews questions was developed to collect information regarding damaged goods from warehouse personnel. The interview questions are directed towards one forklift operator and two warehouse laborers. Based on the interview, the interviewees emphasized on the machinery maintenance issue and the need for providing sufficient training regarding proper warehouse handling to employees.

Process Mapping

The process mapping of MARIO's border commerce procedure is depicted in Figure 1. The analysis of various departments' process mapping revealed several key findings. One of the key findings relevant to this research is that the border operating team should evaluate the efficiency and accuracy of both the unloading and inspection processes at the Myawaddy warehouse, as well as the shipment loading procedures onto container trucks.

Process Performance Metric

In the Measure stage, a process performance metrics, as shown in Table 2, that specifically address the issues of damaged goods was developed. The Damaged Goods Percentage information determines the proportion of goods that have been damaged during the Myawaddy warehouse's complete operational procedure.

Table 2: Calculation of Defect Rates for Torn Goods

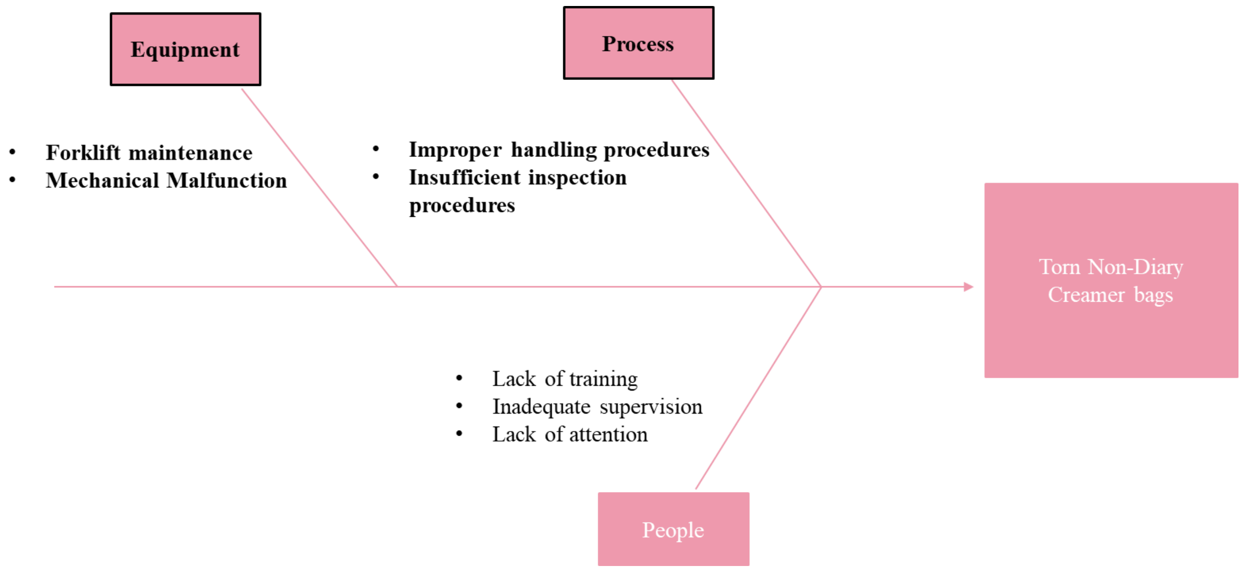
Month	**Total bags**	**No. of torn bags**	**Defect rate**	**Total cost for compensation (MMK)**
March	1040	3	0.29%	600,000
April	1040	1	0.10%	200,000

Fishbone Diagram

The analysis of the fishbone diagram uncovers potential causes of failure in torn nondairy creamer (NDC) bags during the loading and unloading processes as shown in Figure 2.

Based on the diagram, one key finding is that poor handling practices during the loading and unloading of goods exist. It also reveals equipment-related factors that could contribute to the tearing of NDC bags. One significant finding suggests that poor or sporadic maintenance of forklifts may be a contributing factor.

Figure 2: Fishbone Diagram for Torn Non-diary Creamer Bags



FMEA

In the case of the Myawaddy warehouse operation, FMEA is utilized to evaluate the risks related to the problems. According to the FMEA as shown in Table 3, the root causes of warehouse operation are improper handling during transportation and machinery error due to lack of inspections.

The machinery error RPN (Risk Priority Number) has the highest score of 360 based on the FMEA (Failure Mode and Effect Analysis) score. This high score suggests that the biggest risk in the process is caused by faults in the machinery. The insufficiency of quality control protocols is among the primary factors contributing to this risk. Potential problems might go undiscovered if equipment maintenance is ignored and inspections are insufficient. Damaged items and a drop in overall operational efficiency may arise from this error. Frequent occurrences of damaged objects are also a result of inadequate training and a lack of awareness among warehouse staff on safe handling techniques.

PRESENTATION AND CRITICAL DISCUSSION OF RESULTS

Improve

The improvement plan (Table 4) was devised and implemented. This plan aimed to identify effective solutions to existing challenges and enhance overall performance by leveraging their expertise and insights.

Validation of Results

The effectiveness of the improvement plan and the success in addressing issues with damaged items is verified through the validation of outcomes. In late May and early June, an industry expert

Table 3: FMEA

Function	Potential Failure Mode	Potential Effects of Failure	Sev	Potential Cause	Occ	Current Process Controls (Prevent/ Detect)	Det	RPN	Recommended Actions	Responsibility and Target Completion Date
Goods loading and unloading	Torn NDC bags	Compromised product quantity	9	Improper handling during transporta-tion	4	A supervisor overseeing throughout the process	7	252	Provide proper training	Warehouse operation team By June 30, 2023
		Potential loss of sale	9	Machinery error	5	Machine maintenan ce once in three months	8	360	Machine maintenance every month	Warehouse operation team

Table 4: Improvement Plan

Root Cause	Improvement Plan	Action Taken
Improper handling	Strengthen Training Programs	- Conducted two training sessions, provided by an industry expert on May 28 and June 03, 2023.
Machinery Error	Enhance Machinery Maintenance	- Two routine inspections were conducted on May 15 and June 15, respectively. - Scheduled monthly maintenance schedule.
Misunderstanding and miscommunication	Improve Communication and Collaboration	- Established two group chats, one for warehouse operation and one for invoice on LINE and VIBER social platform.

conducted two training sessions for warehouse laborers and forklift drivers to educate them on proper handling practices and safety measures. With strict supervision after these sessions, there were no incidents reported in June, as shown in Table 5.

Table 5: Defect Rate after Improvement Plan

Month	Total bags	No. of torn bags	Defect rate	Total cost of compensation (MMK)
March	1,040	3	0.29%	600,000
April	1,040	1	0.10%	200,000
After 2 sessions of training program				
June	1,040	0	0%	0

C***ontrol***

To further enhance the efficiency of the improvement plan and ensure continued success in addressing issues with damaged items error-proofing approaches is going to be used in the control plan as shown in Table 6.

CONCLUSION

The investigation thoroughly identified the root causes of damaged goods in the warehouse and the factors contributing to invoicing mistakes. Furthermore, practical and sustainable solutions were developed to enhance MARIO's logistics process and document management, improving both quality and efficiency.

Table 6: Error-Proofing Approach Control Plan

Category	Proposed error-proofing approach	Action taken
Strengthen Training Programs	To develop training materials with visual aids, checklists, and step-by-step instructions to ensure consistent and accurate training delivery.	- In discussion with the industry expert for a checklist and step-by-step instructions. - Tentative day to finish by August 30, 2023.
Enhance Machinery Maintenance	- Implemented equipment maintenance checklists with clear visual indicators for the inspection and maintenance tasks to be performed. - Color-coded stickers or tags to indicate the last maintenance date or the next maintenance due date.	- Developed daily checklist for forklift maintenance.

Additionally, this study played a crucial role in supporting continuous improvement efforts for damaged goods, resulting in appropriate adoption recommendations being formulated. Effective implementation of the control plan has yielded impressive results in minimizing defects across warehouse operations. Through enhanced training, supervision, equipment maintenance, and communication protocols, instances of damaged goods have significantly reduced.

The researcher recommended to extend the duration and adopt a longitudinal approach, providing a more comprehensive understanding of the issues and underlying factors related to Lean Six Sigma deployment and enabling a deeper insight into long-term trends and dynamics that impact program effectiveness.

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