MITIGATING MANUAL SORTING FAILURES USING ENHANCED FMEA-BASED RISK PRIORITIZATION: CASE STUDY AT XYZ SHIPPING COMPANY

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Abstract

his study analyzes critical failure modes in the manual sorting process at XYZ Shipping Company using the Failure Mode and Effects Analysis (FMEA) method. The research was conducted over 48 days through direct observation, operational data collection, and interviews with three experienced sorting staff. Five major failure modes were identified: human error, damaged or unreadable labels, unclear address information, incorrect postal codes, and staff fatigue. The FMEA results show that incorrect postal codes represent the highest risk, with an RPN value of 280, followed by unclear address writing (252) and damaged labels (224). These findings indicate that the manual sorting process is highly vulnerable to errors due to its dependence on operator accuracy and the lack of a validation system. The novelty of this study lies in its integration of risk prioritization with targeted mitigation strategies designed specifically for manual import-sorting operations in Indonesian logistics companies, a context that remains underexplored in existing literature. Recommended mitigation measures include implementing an automatic postal code validation system, applying waterproof label materials, and increasing sorting staff capacity to reduce fatigue. The results demonstrate that these interventions have the potential to reduce sorting-related risks by up to 45%, highlighting the practical value of applying FMEA to improve operational reliability in the logistics sector.

Keywords: FMEA, operational risk, sorting process, import shipment.

INTRODUCTION

The significant impact of cross-border e-commerce trade has increased the need for national logistics infrastructure to manage import volumes quickly and accurately (Yulianto & Wulandari, 2025). In this case, the XYZ shipping company is one of the key centers for handling various domestic and international shipments. The XYZ shipping company is strategically responsible for ensuring that the flow of imported goods moves smoothly. However, manual sorting is the most vulnerable step in this process because it is naturally prone to operational failures (Supardi & Alkhorni, 2019) Delays in postal deliveries have become a major problem for delivery service companies (Kudlá et al., 2017), and failures in this processing directly impact the timeliness of services (Charles Marsello Hersanto et al., 2023).

There are major problems in the processes at the XYZ shipping company, namely human error caused by operator fatigue, lack of communication between senders and recipients, and labels that are often damaged or illegible. These working conditions are exacerbated by the fact that operators must rely on visual accuracy to process large numbers of shipments (Kurniawan et al., 2024) As shown by case studies of other shipping companies, processing failures can lead to delivery problems that exceed the company's tolerance limits (Bisma, M. A; Aryasanti, 2022). Barcode-based automatic sorting systems has been developed as an alternative solution to improve efficiency (Huang et al., 2025) and reduce errors (Nuryana & Latifa, 2022). However, implementing this technology requires significant capital and time investment. As a result, it is crucial to proactively manage and mitigate risks in existing systems (Wang et al., 2024).

The urgency of this research lies in identifying critical failure sources in the manual sorting process and providing quick and structured mitigation solutions. The Failure Mode and Effects Analysis (FMEA) method was chosen for its reliability in analyzing risks and measuring failures through the calculation of Risk Priority Number (RPN) values (Purnomo et al., 2024), which allows companies to concentrate on failure modes with the highest impact and frequency (Suyatno et al., 2025). Therefore, the purpose of this study is to analyze

the risk of failure in the sorting process at XYZ shipping company using FMEA and to make risk-based improvement recommendations to reduce operational losses. In practical terms, the results of this study are expected to help managers create effective mitigation programs. Furthermore, this study contributes theoretical and practical novelty by developing a structured mitigation framework specifically designed for manual sorting environments that remain dominant in logistics operations in Indonesia and other developing countries. Unlike previous studies that only focused on error identification, this research emphasizes prioritized corrective actions through FMEA-based risk assessments, providing actionable solutions that logistics managers can apply to enhance operational accuracy and cost efficiency. Thus, this research offers a strategic foundation for risk-based improvement initiatives in the postal and shipping industry, especially in transitional operational systems that have not fully implemented automation.

METHODOLOGY

This study uses a quantitative descriptive approach with a case study on the sorting process of imported shipments at XYZ Shipping Company. Data collection was conducted through direct observation of sorting activities for forty-eight days, interviews with three officers involved in the operational process, and analysis of supporting documents related to the work process and sorting accuracy levels. The collected data was then processed and analyzed using the Failure Mode and Effect Analysis (FMEA) method to identify potential failures, assess their impact, and determine mitigation priorities based on Risk Priority Number (RPN) calculations.

The analysis process in this study was conducted systematically and structurally in accordance with the stages in the research methodology. Broadly speaking, the research methodology is described through a process flow from the initial stage to the stage of determining mitigation recommendations. These stages consist of data collection activities through observation and interviews, identification of failure modes that arise during the sorting process, assessment of severity, frequency of occurrence, and the system's ability to detect potential failures (detection)(Ahmad et al., 2023). These values are then used to calculate the RPN (Salah et al., 2023). Next, an evaluation is carried out based on the priority of the risk value to determine the most appropriate mitigation measures to be applied within the scope of the company's operations.

The research flow is visualized in a diagram showing the interrelationship of each stage of analysis related to the FMEA risk control process. The research methodology flowchart can be seen in Figure 1 below.

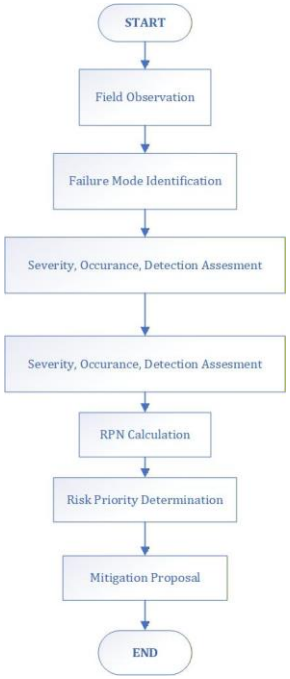

Figure 1. Methodology Flowchart

After mapping the methodology flow through the diagram Figure 1, the next step is to conduct an in-depth analysis of each potential failure identified in the sorting process. Risk assessment is carried out by assigning a rating scale to three main aspects, namely the severity of the impact on operational processes, the likelihood of failure occurring, and the system's ability to detect the failure before it impacts the next stage. These three parameters are then multiplied to obtain a Risk Priority Number (RPN) value, which is the main reference in determining the urgency level of risk control.

The RPN calculation results are then sorted from the highest to the lowest value, making it easier to determine the mitigation priorities that require immediate corrective intervention (Ratnamurni et al., n.d.). The final stage of this methodology is the preparation of practical mitigation recommendations that can be directly applied to the operational environment of XYZ Shipping Company to improve the accuracy of the sorting process and reduce the possibility of errors in the future. Through this approach, it is hoped that the company will be able to make data-driven decisions in an effort to improve process effectiveness and service quality to customers.

The data used in this study consists of primary and secondary data. Primary data was obtained through direct observation of the sorting process and interviews with three sorting staff members who had more than five years of experience. Meanwhile, secondary data was obtained from internal company documents, daily operational reports, and literature related to risk management and the application of Failure Mode and Effects Analysis (FMEA) in the field of postal logistics. Data collection was carried out in three stages, namely direct observation of the manual sorting process to identify the types of failures and their frequency, as well as interviews with sorting staff to understand the main causes of failure and the control systems in place.

Data analysis was performed using the Failure Mode and Effects Analysis (FMEA) method through several steps, namely identifying the failure modes or types of failures that occurred, determining the severity (S) value to measure the severity of the impact of the failure, occurrence (O) to measure the frequency of occurrence, and detection (D) to measure the system's ability to detect errors. The Risk Priority Number (RPN) value was calculated using the formula RPN = S × O × D (Fernando et al., 2022), and the results were used to determine the priority of risks that needed to be mitigated immediately.

After the stages were mapped visually through the presented flowchart, the next step was to carry out in-depth analysis on each identified failure mode to obtain a comprehensive assessment of the operational risks occurring during the sorting process. The RPN results were then ranked from the highest to the lowest to determine the most critical risks that could significantly impact the performance of the sorting system. Based on this priority, mitigation recommendations were formulated by considering practical improvements that could be directly implemented by XYZ Shipping Company, especially those related to strengthening the accuracy of the sorting process and reducing the likelihood of repetitive failures. Through this structured methodological approach, this research provides scientifically based recommendations to enhance operational reliability and service performance in parcel sorting activities.

RESULT AND DISCUSSION

Based on observations, various data were obtained showing that the manual sorting process at XYZ shipping company has a high risk of failure, mainly due to human factors, the physical condition of labels, and the limitations of the manual system used. Based on the data collected, it was found that the most common type of failure was postal code errors, followed by unclear addresses, damaged labels, human error, and staff fatigue. These findings indicate that a manual work system that is entirely dependent on operator accuracy is highly prone to error, especially when shipment volumes increase.

Table 1 shows that out of a total of 98 incidents over 48 days, incorrect postal codes ranked highest with 25 cases (25.51%), followed by damaged or unreadable labels (20.41%) and unclear addresses (18.37%). This indicates that more than half of the incidents were caused by errors in the address and postal code

identification stage. This condition is relevant to the research objective, which is to identify the most critical risks in the manual sorting process in order to prioritize mitigation strategies.

Table 1. Frequency of Failure Types

No	Type of Failure / Problem	Number of Occurrences	Percentage (%)	Average Incidents per Day
1	*Human Error*	17	17,35%	1 case
2	Damaged or unreadable label	20	20,41%	1 case
3	Unclear address	18	18,37%	1 case
4	Incorrect postal code	25	25,51%	2 case
5	Staff fatigue	18	18,37%	1 case
Total		98	100%	

Source: Author's Own Work, 2025

The results of the Failure Mode and Effects Analysis (FMEA) as presented in Table 2 show that the highest Risk Priority Number (RPN) value is found in the failure of incorrect postal codes (280), followed by unclear address writing (252) and damaged or unreadable labels (224). High RPN values indicate that these three types of failures have the potential to significantly impact delivery delays and increase operational costs. In the operational context of the XYZ shipping company, postal code errors are the main cause of distribution delays because the correction process can only be carried out after the package arrives at the wrong Delivery Center. This condition results in a low Detection value because the system is unable to detect errors before the shipment changes location.

Table 2. Failure Mode and Effects Analysis (FMEA) Results

No	***Failure Mode***	S Severity	O Occurance	D Detection	RPN = SxOxD
1	*Human Error*	7	6	5	210
2	Damaged or unreadable label	8	7	4	224
3	Unclear address	7	6	6	252
4	Incorrect postal code	8	7	5	280
5	Staff fatigue	6	7	4	168
Total		7,2	6,6	4,8	226,8

Source: Author's Own Work, 2025

These findings are in line with the results of a study (Supardi & Alkhorni, 2019) which states that the manual sorting system at XYZ Shipping Company has a high level of dependence on operator accuracy, which leads to an increase in human error. Research (Nuryana & Latifa, 2022) reinforces that the implementation of a barcode-based sorting system and automatic conveyors can reduce the error rate by up to 50%. Therefore,

the implementation of an automatic postal code validation system and the use of waterproof labels are relevant and effective mitigation measures.

Further analysis shows that staff fatigue also contributes to an increased risk. Based on interviews, sorting staff are faced with a high workload without any rotation between staff members to perform sorting, and there are only three sorting staff members. This condition causes a decrease in concentration and increases the chance of input or label reading errors. This phenomenon is supported by research (Supardi & Alkhorni, 2019) stating that work fatigue is directly proportional to an increase in operational errors in the manual sorting process. Thus, there needs to be a managerial policy that balances the workload and increases the number of sorting staff to maintain productivity.

Overall, the findings of this study indicate that the Failure Mode and Effects Analysis (FMEA) method is effective in identifying and prioritizing operational risks in the manual sorting process for imports. The application of this method provides practical benefits for XYZ shipping company , especially in developing managerial decisions to accelerate operational processes. Furthermore, theoretically, this study supports the use of Failure Mode and Effects Analysis (FMEA) in postal logistics and provides a foundation for the development of automated systems in the future. Therefore, the results of this study are in line with the study objectives, which are to provide recommendations based on risk priorities to reduce operational costs and improve logistics efficiency at XYZ shipping company.

CONCLUSION

Based on the results of research on the application of the Failure Mode and Effects Analysis (FMEA) method in the sorting process at XYZ Shipping Company, it can be concluded that the manual sorting process currently in use has several potential failures that directly impact the speed and accuracy of import shipment delivery. Through direct observation and in-depth analysis, five main types of failures were identified, namely incorrect postal code determination, damaged or unreadable shipment labels, unclear recipient addresses, human error committed by officers, and officer fatigue due to high workloads. The Risk Priority Number (RPN) calculation shows that postal code errors are the type of failure with the highest level of risk. This occurs because the sorting system is not equipped with an automatic validation mechanism that can ensure the conformity between the postal code and the destination address. Other types of failures, such as unclear addresses and damaged labels, also have a fairly high RPN value, which requires the company's attention. The results of this analysis prove that the FMEA method is able to provide a more focused picture of the urgency of operational risks, enabling the company to take preventive measures earlier before these failures impact customer service.

Through the mitigation strategies recommended in this study, such as the implementation of a technology-based postal code validation system, the use of good quality labels, and the optimization of employee work schedules to reduce fatigue, companies can improve the reliability of the sorting process and significantly reduce error rates. Thus, the results of this study contribute to improving the effectiveness of logistics processes, operational cost efficiency, and service quality for customers. Overall, this study confirms that the application of FMEA as a risk assessment tool can be an appropriate reference in continuous improvement efforts in the logistics sector, particularly in the highly complex activity of sorting imported shipments. The implementation of the mitigation recommendations provided is expected to support the achievement of company performance targets and provide a better service experience for customers in the future.

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