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ANALYSIS OF DELIVERY DELAYS USING *STATISTICAL PROCESS CONTROL* AT 3PL COMPANY

Jenni Br Tarigan[1], Syarif Hidayatuloh[2*], Nabila Noor Qisthani[3], Yulinda Uswatun Kasanah[4]
Department of Logistics Engineering, Universitas Telkom[1,2,3,4]
Corresponding e-mail*: syarif@telkomuniversity.ac.id

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Abstract

This study aims to analyze the causes of delivery delays at PT XYZ. Delivery delays have become a critical issue as they can affect customer trust and result in potential losses for the company. The study identifies two main causes of delivery delays: shipping schedules and the aging (storage time) of goods in the warehouse. The method used in this research is Statistical Process Control, which involves several analytical tools such as P-chart, Pareto diagram, fishbone diagram, histogram, and scatter plot. The analysis results show that shipping schedules have a significant impact on delivery delays, with several delivery periods falling outside the upper control limit and lower control limit. Additionally, goods aging exceeding seven days also contribute to delays. Other influencing factors include human aspects (data entry errors), environmental factors (bad weather and changes in shipping schedules), methods (schedule mismatches), and measurements (inaccurate stock data). The study recommends several improvements to enhance delivery efficiency, including optimizing stock recording processes, strengthening work discipline, and improving human resource quality through operational training.

Keywords: *Statistical Process Control, Delay, Shipment, Operational*

Abstrak

Penelitian ini bertujuan untuk menganalisis faktor-faktor yang menyebabkan keterlambatan pengiriman barang di PT XYZ. Masalah keterlambatan pengiriman merupakan isu krusial karena dapat memengaruhi kepercayaan pelanggan serta berpotensi menimbulkan kerugian bagi perusahaan. Penelitian ini mengidentifikasi dua penyebab utama keterlambatan pengiriman, yaitu jadwal keberangkatan kapal dan aging (umur simpan barang) di gudang. Metode yang digunakan dalam penelitian ini adalah *Statistical Process Control*, dengan melibatkan berbagai alat analisis seperti *P-chart*, diagram Pareto, *fishbone diagram*, histogram, dan *scatter plot*. Hasil analisis menunjukkan bahwa jadwal keberangkatan kapal memiliki dampak signifikan terhadap keterlambatan pengiriman, di mana beberapa periode pengiriman berada di luar batas kendali atas dan luar batas kendali bawah. Selain itu, *aging* barang yang melebihi tujuh hari juga menjadi faktor penyebab keterlambatan. Faktor lain yang turut memengaruhi meliputi aspek manusia (kesalahan dalam entri data), lingkungan (cuaca buruk dan perubahan jadwal kapal), metode (ketidaksesuaian jadwal), serta pengukuran (ketidakakuratan data stok). Penelitian ini merekomendasikan beberapa langkah perbaikan untuk meningkatkan efisiensi pengiriman barang, antara lain optimalisasi proses pencatatan stok, peningkatan disiplin kerja, serta pengembangan kualitas sumber daya manusia melalui pelatihan operasional.

Kata Kunci: *Statistical Process Control, Delay, Shipment, Operational*

1. Introduction

Third-party logistics (3PL) companies play a strategic role in supply chain management, especially through collaboration and integration in logistics management. This collaboration covers various aspects ranging from inventory management, transportation, to final distribution to customers (Panayides & So, 2005). As a logistics service provider, 3PL companies are required to manage the supply chain effectively to improve operational efficiency and provide optimal customer satisfaction (Santhanakrishnan, 2017). One of the main indicators that reflect the quality of service of logistics companies is the timeliness of delivery of goods (Tanaka et al., 2019). This is a key factor in maintaining the company's reputation and maintaining customer loyalty

Delivery timeliness has a significant impact on customer satisfaction. In an era of increasingly competitive business competition, customers expect fast and on-schedule delivery of goods (Palupi Robustin et al., 2024). Delivery delays not only affect customer trust but can also cause financial losses for the company. The potential loss of customers who switch to other logistics service providers is a big risk that must be anticipated by 3PL companies. Therefore, ensuring on-time delivery is a top priority in a logistics company's operational strategy.

PT XYZ is one of the 3PL companies in Indonesia that focuses on providing integrated logistics services. The company specializes in *Project Logistics* and *Total Solution Logistics*, covering a wide range of logistics services from planning to execution of goods delivery. As a growing company, PT XYZ strives to meet customer needs through efficient logistics management and improved service quality. However, the main challenge faced by this company is to ensure the delivery of goods in accordance with the predetermined target time.

PT XYZ's target delivery time varies based on the distribution destination. For example, shipments from Surabaya to the West Java area have a target time of 2 days, while for the Sumatra area it ranges from 5-7 days. Shipments outside Java, which use sea transportation, take longer because they depend on the ship's schedule and loading and unloading time at the port. This target time greatly affects the company's operational performance, as any delays can result in a decrease in customer confidence. If left unchecked, this could potentially lead to customer loss and impact business sustainability. Delivery delays at PT XYZ are caused by a variety of things, including inconsistent implementation of SOPs (Standard Operating Procedures), lack of monitoring of the delivery process, natural conditions such as bad weather, changes in delivery schedules, mismatches in fleet arrival schedules, and unexpected government regulations. This complexity demonstrates the need for a systematic approach to identify, analyze, and address the root causes of delivery delays.

The problems in the company can be overcome with the *Statistical Process Control* (SPC) approach as a relevant solution. SPC is a technique used to monitor and control operational processes through the use of statistical tools such as *control charts*, Pareto diagrams, *fishbone* diagrams, and others (Evant et al., 2023). The SPC method can be used to monitor and control production or operational processes using statistical tools (Kurnia et al., 2021). Companies can also identify variability in the goods delivery process, understand the root causes of delays, and design appropriate corrective actions using the method.

In the context of logistics, SPC not only helps reduce process variability but also plays a role in improving operational reliability (Attaqwa et al., 2021). Tools such as *control charts* can be used to monitor delivery data in real-time and detect anomalies in the delivery process. Pareto diagrams help companies identify the main factors that cause delays, while *fishbone* diagrams allow in-depth analysis of these causes (Alifka & Apriliani, 2024). Starting from the existing problems, the author proposes a study related to the analysis of delivery delays using the SPC method. Through the application of SPC, PT XYZ can improve the efficiency of the goods delivery process in a measurable and data-based manner. This step also helps the company to be more proactive in facing operational challenges, especially those related to delivery time variability. Thus, SPC becomes an important tool to drive improvements in logistics service quality and maintain customer satisfaction.

The problem of late delivery experienced by PT XYZ is an important basis for this research. By considering the existing complexity, this research aims to analyze the causes of late delivery of goods using the Statistical Process Control (SPC) method. This research is expected to produce practical solutions for the company to overcome the problem of delays while improving the quality of its logistics services. The application of the SPC method is expected to not only help PT XYZ in reducing delivery delays, but also become a reference for other logistics companies facing similar challenges. Through this approach, this research is expected to make a meaningful contribution in improving operational efficiency and effectiveness in the logistics industry.

2. Research Methods

2.1. Subjects and Objects of Research

In research on delays in goods, the object of research is the factors that affect the delay in delivery of goods and the prediction of delays in goods in the future. The research subject is the entity that is the main source of data to be analyzed by the researcher. These subjects can be individuals, groups, organizations, or certain phenomena. The subject in this research is PT XYZ which is a 3PL company in the field of logistics services.

2.2. Data Collection Technique

Observations were made by direct observation in the field to obtain more accurate information about the object of the problem under study. The data collected includes the flow of the goods delivery process and the number of goods that experience delays in delivery. In addition, interviews were also conducted as a data collection method, where several questions were prepared in advance to suit the topic of the problem being discussed. Interviews were conducted with experts in each section to find out the causes, impacts and possible risks.

2.3. Data Analysis Technique

The data that has been obtained is then processed using the SPC method with the following steps:

1. Collect late delivery data using a check sheet.
2. Create a histogram to visualize the data.
3. Identify the relationship between different types of delays using scatter diagrams.
4. Create a proportion control map (P-Chart) to monitor process stability.
5. Identify the most dominant causal factors using a fishbone diagram.

3. Results and Discussion

a. Check Sheet

The first step in the Statistical Process Control Method is to compile and fill out a check sheet that serves to collect data to identify problems based on their type or cause. PT XYZ determines that high aging (shelf life of goods) can be one of the factors causing delivery delays. Based on the calculation results, the performance of officers in the warehouse has not reached the set target, so the goods stored in the warehouse have a high aging. The complete results of the calculation can be seen in Table 1.

Table 1. *Check Sheet* Results

Week	**Ship Quantity (Unit)**	**Delay Type**		**Number of Latecomers**
		Shelf Life of Goods (*Aging*) >7 days	**Ship Departure Schedule**	
1	485	20	131	151
2	697	23	367	390
3	1068	31	154	185
4	591	26	93	119
5	888	57	129	186
6	560	67	48	115

7	341	12	135	147
8	697	47	24	71
9	674	16	11	27
10	698	29	25	54
11	568	12	27	39
12	370	10	63	73
13	551	4	64	68

Table 1. shows that the number of shipments varies every week with the highest peak in the 3rd week of January at 1068 shipments and the lowest in the 12th week of March with 371 shipments, but in the 13th week the number of shipments increased by 180. The highest number of late items in week 2 was 390. Based on the table above, it can be seen that the most common type of delay occurs in changes to ship departure schedules. This shows that ship departures have the potential to make goods delivered late to customers.

b. Histogram

Histogram is a bar chart that displays the amount of data to be presented. Figure 1. shows a histogram of the types of delays identified through the *aging of* goods and ship departure schedules. In the figure below, it can be seen that changes in ship departure schedules dominate the level of non-conformity to standards, causing delays in delivery. This condition requires further analysis to determine the causal factors.

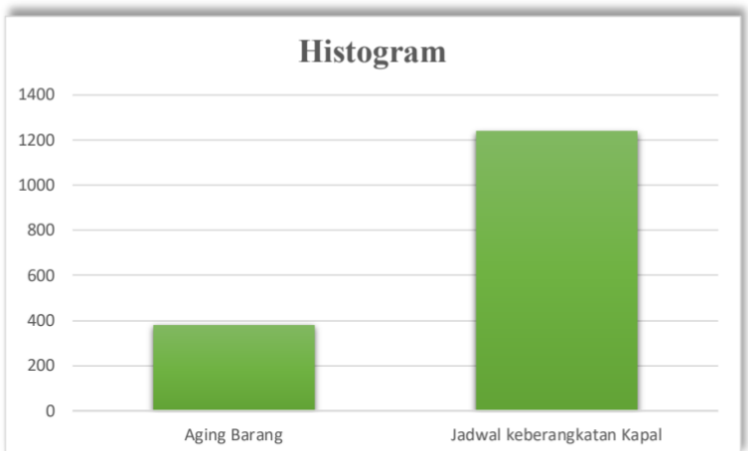

Figure 1. Delay Histogram

c. Control map (P-chart)

P-chart control maps have the benefit of assisting delivery quality management and can provide insight into the best time and location for quality improvement (sinha). The first step is to determine the *center line*, also known as the *center line* on a P-chart. The center line is the line that runs between the lower control limit (LCL) and the upper control limit (UCL). The average percentage of late deliveries is shown by the center line. The following formula is used to obtain the center line and calculate the upper control limit (UCL) and lower control limit (LCL), the upper control limit and lower control limit are indicators of the statistical size of a process can be said to deviate or not (Aini et al., 2017):

a. Calculating *Center line* and Percentage of Damage

$$p = \frac{np}{n} \quad (1)$$

$$p = \frac{131}{485} = 0{,}27$$

$$Cl_1 = \bar{p} = \frac{\sum np}{\sum n} \quad (2)$$

$$Cl_1 = \bar{p} = \frac{1271}{8189} = 0{,}155$$

b. Calculating the Upper Control Limit (UCL)

$$UCL_1 = \bar{p} + 3\frac{\sqrt{\bar{p}(1-\bar{p})}}{n} \quad (3)$$

$$UCL_1 = 0{,}155 + 3\frac{\sqrt{0{,}155\ (1-\overline{0{,}155})}}{630} = 0{,}198$$

c. Calculating the Lower Control Limit (LCL)

$$LCL_1 = \bar{p} - 3\frac{\sqrt{\bar{p}(1-\bar{p})}}{n} \quad (4)$$

$$LCL_1 = 0{,}155 - 3\frac{\sqrt{0{,}155\ (1-\overline{0{,}155})}}{630} = 0{,}112$$

Table 2. P-Chart Calculation Results

Week	Send Amount	Departure Schedule	P	p̄	UCL	LCL
1	485	131	0,270	0,155	0,198	0,112
2	697	123	0,176	0,155	0,198	0,112
3	1068	154	0,144	0,155	0,198	0,112
4	591	90	0,152	0,155	0,198	0,112
5	888	56	0,063	0,155	0,198	0,112
6	560	69	0,123	0,155	0,198	0,112
7	341	112	0,328	0,155	0,198	0,112
8	697	88	0,126	0,155	0,198	0,112
9	674	121	0,180	0,155	0,198	0,112
10	698	87	0,125	0,155	0,198	0,112
11	568	74	0,130	0,155	0,198	0,112
12	371	63	0,170	0,155	0,198	0,112
13	551	69	0,125	0,155	0,198	0,112
TOTAL	**8189**	**1237**				

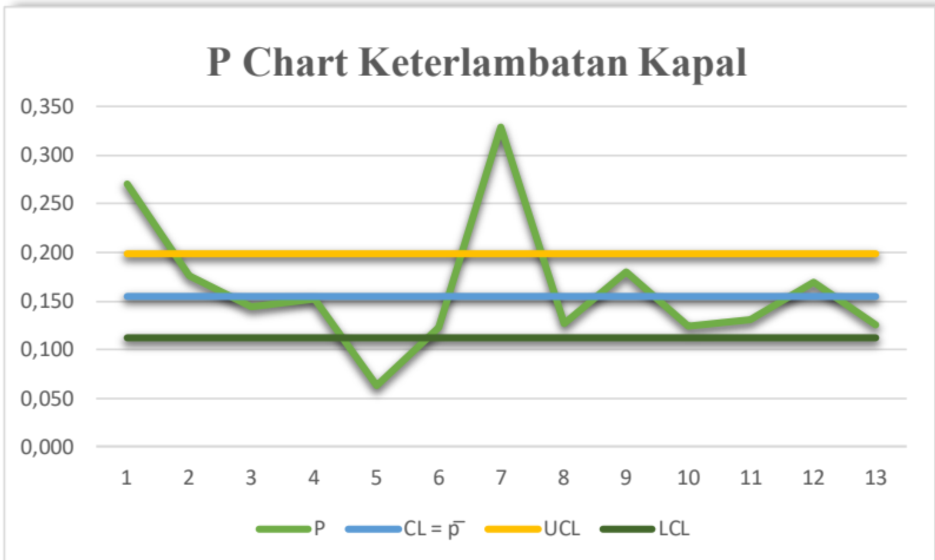

Figure 2. P-chart of Ship Delay

Figure 2. shows the control map for the type of delay due to ship schedule changes, where the UCL (upper control limit) and LCL (lower control limit) values are 0.198 and 0.112, respectively. If the proportion of delays is above (LCL) or below (UCL), this indicates a problem in the process that requires corrective action. Of the 13 points, there are only 10 points that are between the UCL and LCL lines indicating safe limits. There are two points that are above the upper control limit (UCL) and there is one point that is below the lower control limit (LCL), all three points are outside the limit point of the excusable delay of goods. This is an early indicator that the condition of the process needs to be reviewed due to the appearance of points outside these control points, therefore the shipping process needs to be evaluated as soon as possible, and preventive measures need to be taken.

d. *Fishbone Diagram*

Fishbone Diagram, also known as *Cause-and-Effect Diagram* ((Holifahtus Sakdiyah et al., 2022)Ishikawa *Diagram*), is a visual tool used to identify, analyze, and organize the various possible causes underlying a particular problem or effect. This cause-and-effect diagram is designed to illustrate the causal factors of each previously identified case of late delivery. The cause-and-effect diagram related to late delivery can be seen in Figure 3.

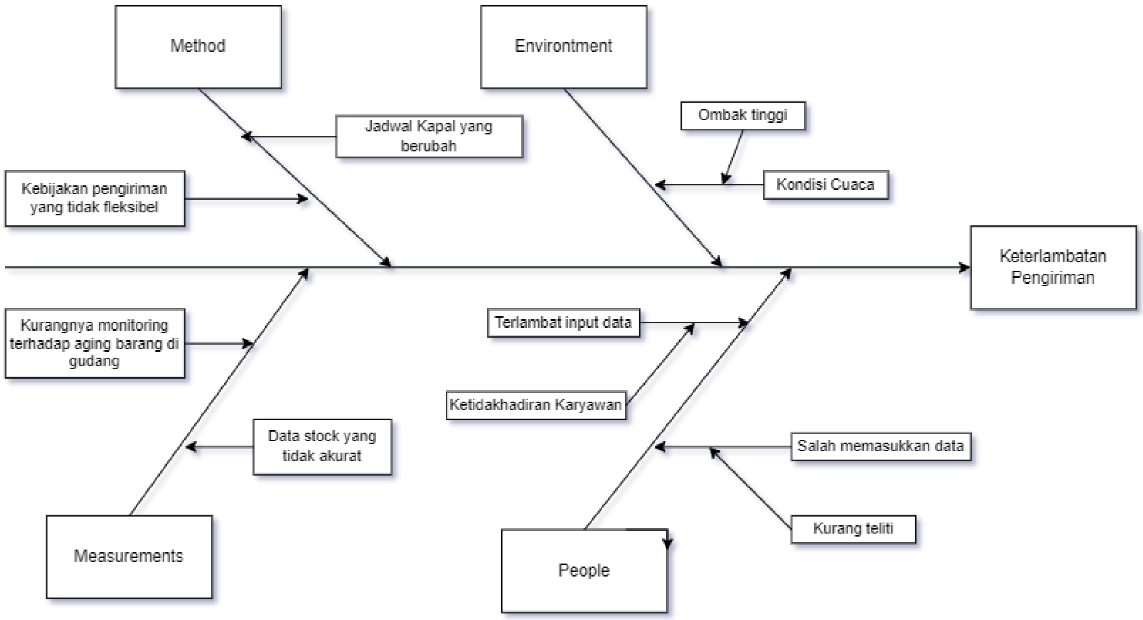

Figure 3. *Fishbone* Diagram

Based on the *fishbone* diagram that has been made, there are four main elements that affect the delay in delivery of goods, namely: *People*, *Environment*, *Method*, and *Measurement*. The Method and *Measurement* components are interrelated because of problems with inaccurate stock data and lack of monitoring of aging goods in the warehouse. This can worsen delivery arrangements that become inflexible. If the techniques or methods used do not allow for quick modifications or improvements, measurement and monitoring issues will further exacerbate delivery delays. Therefore, flexible arrangements and careful preparation are necessary to overcome these problems.

Environmental factors, such as bad weather and changes in vessel schedules, also have a significant impact on the delivery process. Although often out of control, these environmental conditions need to be anticipated with more adaptive and dynamic delivery planning. In addition, the *People* component plays a key role in the efficiency of the delivery process. Employee absenteeism and data entry errors are often sources of problems that can be addressed through the provision of clear instructions, adequate training, and effective human resource management. Individual accuracy and responsibility in data entry also need to be improved to prevent errors. To prevent delays in the delivery of goods, preventive measures need to be taken, such as improving the accuracy of stock data, stricter monitoring, improving management methods, and anticipating environmental risks. Thus, delivery efficiency can be improved, and the risk of delays can be minimized.

e. Scatter Diagram

A scatter diagram can be used to determine whether there is a positive or negative relationship between the quantity of shipments and the quantity of vessel delays. The diagram illustrates the breakdown of the correlation between the quantity of shipments and the quantity of vessel delays that occur. Through this diagram, the relationship between the two variables can be analyzed to understand the pattern of delays that may be associated with the number of shipments.

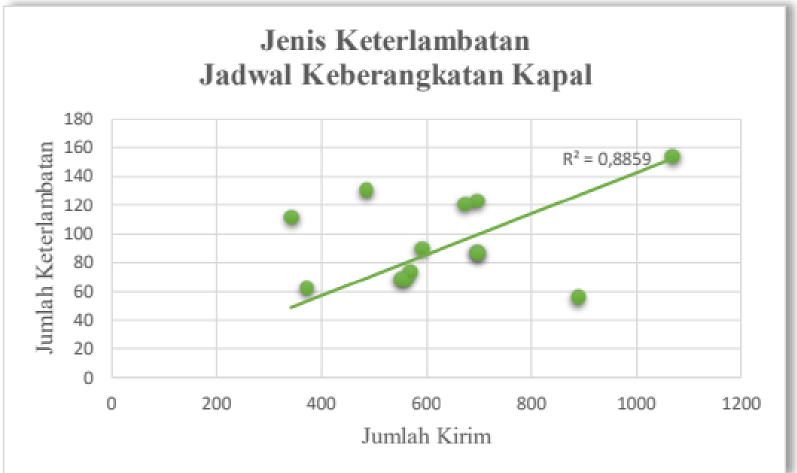

Figure 4. *Scatter* Diagram

Based on Figure 4. which shows a *scatter* diagram, it can be seen that there is a positive relationship between the number of shipments and the number of delays. This is indicated by the regression line having a positive slope, which means that as the number of shipments increases, the number of delays also tends to increase. The coefficient of determination (R^2) of 0.8859 indicates that approximately 88.59% of the variability in the number of delays can be explained by the variability in the number of deliveries. This value is high, indicating that the linear regression model used is good enough to explain the relationship between the two variables.

f. Flowchart

Flow charts are used to illustrate each step involved in carrying out an operational process. This diagram makes it easier to examine the procedure as a typical shipping protocol to reduce the number of delays in product delivery. The process begins with the warehouse receiving materials from suppliers or vendors and conducting an inspection of the goods. If the goods pass the inspection, the next step is to prepare the Berita Acara Serah Terima (BAST), which is then forwarded to the contract logistics team. The next process of shipping goods follows the stages depicted in the flowchart in Figure 5.

The process begins when the supplier sends goods to the PT XYZ warehouse. Upon arrival, the warehouse conducts an inspection of the goods. If the inspection deems the goods safe, the warehouse issues a BAST (Receipt Handover Report), which is forwarded to the logistics contract team. The team then inputs the receiving information, and the warehouse issues an Outstanding Cargo report. Following this, the logistics contract department prepares a loading list for shipment. If the goods are found to be unsafe during the inspection, the warehouse contacts the customer to confirm the status of the damaged goods. Based on the customer's response, the goods are either returned to the supplier if rejected or repaired (repackaged) if accepted.

Once the loading list is prepared, it is simulated in the warehouse's stuffing plan. If the simulation matches the requirements, the loading list is forwarded to ATR -the subsidiary of PT XYZ, where a Bay Plan and EIR (Equipment Interchange Receipt) for the containers are prepared. If the simulation does not match, the loading list is updated and re-simulated until it is accurate. The finalized loading list is then sent to the traffic team, which arranges for transport vehicles and confirms truck availability. Finally, the goods are loaded onto the trucks and shipped to the port, marking the end of the process. This structured flow ensures proper inspection, handling, and shipping of goods, providing an efficient and detailed method for logistics operations.

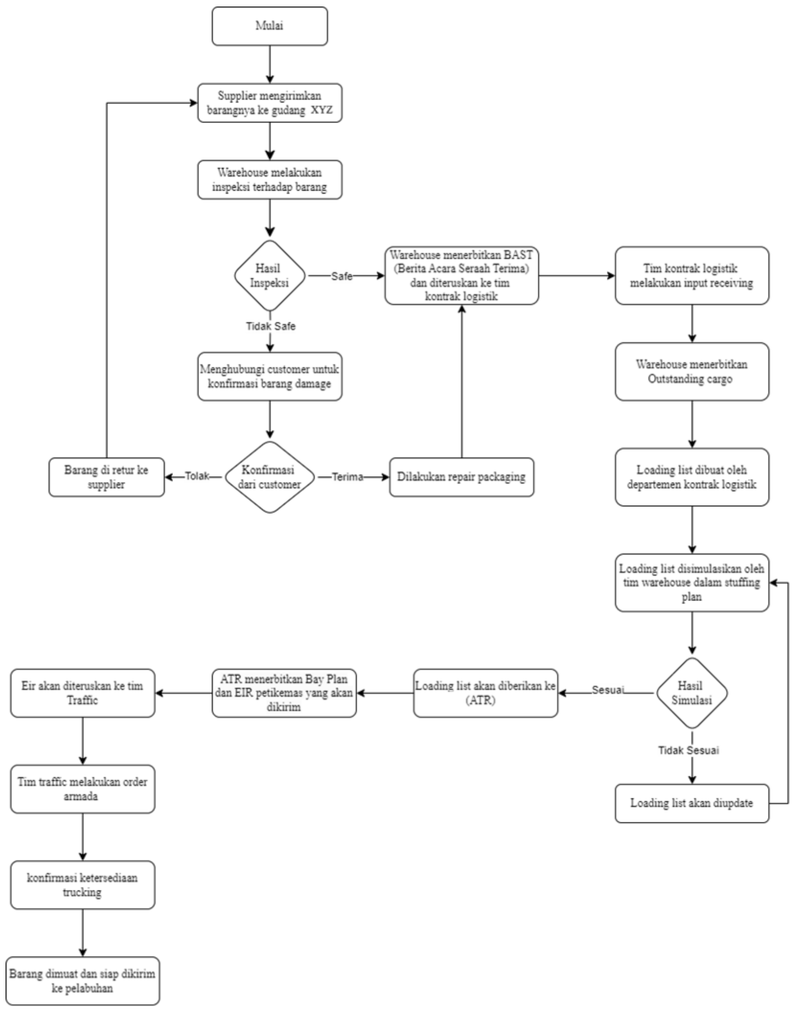

Figure 5. Flow Chart

4. Conclusion

The causes of shipping delays at PT XYZ can be classified into two main types, namely ship departure schedules and *aging* (shelf life of goods) in the warehouse. The factors that support these delays include *people*, *environment*, *method*, and *measurement*. Human factors contribute through errors in data entry, while environmental factors affect changes in ship departure schedules due to poor weather conditions. Measurement factors have an impact on the number of undelivered goods in the warehouse, and method factors affect how the delivery schedule is determined. Based on the analysis using 7 tools in the *Statistical Process Control* method, it is known that the ship departure schedule has a greater influence than the *aging of* goods in causing delivery delays.

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