Analysis of The Causes of Delays In Cement Delivery At CP Tuban Using The FTA and FMEA Methods At PT XYZ

Fahrizal Dwi Prasetya[1*], Efta Dhartikasari Priyana[2], Purwanto[3]

[1,2,3]Program Studi Teknik Industri, Fakultas Teknik, Universitas Muhammadiyah Gresik
Jalan Sumatera N0. 101, Gresik Kota Baru (GKB), Kabupaten Gresik, Jawa Timur, 61121, Indonesia
*Coresponden author:
Email: fahrizaldwiprasetya4@gmail.com

Abstract.
On-time delivery is a key indicator for maintaining smooth supply chain operations and ensuring customer satisfaction in cement distribution. However, between May and August 2026, cement shipments from CP Tuban experienced 3,420 instances of delay, primarily due to issues related to inventory levels, the goods release process, and excessive parking duration. This study aims to identify the causes of these delivery delays, determine which causes require the most urgent attention, and propose improvements. The Fault Tree Analysis (FTA) method is used to map the causes of delays into a hierarchical structure, while Failure Mode and Effects Analysis (FMEA) is employed to assess the risk of each cause via a Risk Priority Number (RPN). Data were collected through interviews with the General Manager and the Head of the Logistic Control Tower team, questionnaires assessing severity, occurrence, and detection (completed by two respondents), as well as On-Time Delivery (OTD) data and Root Cause Analysis (RCA). The FTA identified 14 basic events categorized under warehouse constraints, driver-related issues, and accidents all linked via OR gates, meaning each can directly lead to a delay. The FMEA yielded RPN values ranging from 48 to 448, with the four highest-priority issues being: failure to adhere to maintenance schedules (448), failure to complete equipment checklists (392), drivers neglecting to provide confirmation via the application (378), and drivers taking excessively long breaks (324). Improvements are proposed using the 5W+1H framework, including automated maintenance schedule reminders, mandatory digital equipment checklists to be completed prior to departure, automated confirmation prompts within the driver application, and automated notifications combined with the tracking of driver parking duration. The combination of FTA and FMEA not only identifies the causes of delays but also determines which causes should be prioritized for improvement.
Keywords: *delivery delay, Fault Tree Analysis, Failure Mode and Effects Analysis, Risk Priority Number and cement logistics.*

I. INTRODUCTION

Timely delivery is an important factor in distribution activities because it is related to the smooth running of the logistics process and fulfilling customer needs.[1] [2]The shipping process involves several interconnected stages, from fleet preparation, departure, travel, to receiving the goods at the destination.[3]Disruptions at any of these stages can cause delivery delays. Therefore, companies need to monitor and evaluate the distribution process to identify the factors causing delays and determine appropriate corrective measures.[4].

PT XYZ is a company engaged in logistics services and distribution of cement and non-cement products. In carrying out distribution activities, the company has a Control Tower department tasked with monitoring fleet movements and delivery status. This monitoring utilizes several types of On Time In Full (OTIF) data, namely Claim OTIF, Factory Arrival OTIF, and Shipping OTIF or On Time Delivery (OTD). OTD data is used in this study because it is related to the timeliness of cement delivery to its destination.

Table1Delay Data

Region	May	June	July	August	Total
CP Indarung	1419	529	100	124	2172
CP Rembang	886	760	442	379	2467
CP Sbi Tuban (Dynamix)	212	130	121	115	578
CP Tuban	892	815	696	1017	3420
DC Banyuwangi Si	14	0	0	0	14
DC Buffer Gresik (Plant)	101	88	81	95	365
Dumai GP	7	3	0	0	10
Celukan Bawang PP (Gerokgak)	22	68	44	91	225
Bengkulu PP	88	34	0	0	122
Gud. Sid Gulomantung, Gresik	0	0	1	0	1
Total					9374

Source: Data of PT XYZ

Based on Table 1, data on delivery delays from May to August 2026, a total of 9,374 cases of late deliveries

were recorded across all of PT XYZ's distribution areas. Of these data, CP Tuban recorded the highest number of delays, with 3,420 incidents. The number of delays at CP Tuban in May reached 892 incidents, then decreased to 815 incidents in June and 696 incidents in July. However, in August the number of delays increased again to 1,017 incidents. This condition indicates that late deliveries at CP Tuban remain a problem that requires further analysis to identify the causal factors and determine appropriate corrective measures.

To find out the cause of the delay, it is necessary to identify the factors that influence the delivery process.[5]Based on data on delivery delays and interviews with relevant parties at the Logistics Control Tower, the causes of delays are grouped into three main categories: warehouse constraints, driver constraints, and accidents. These three categories encompass several events that can hinder the delivery process, such as long unloading queues, driver constraints, and incidents that disrupt fleet operations. However, identifying these categories is not sufficient to determine which causes need to be prioritized and the level of risk they pose to the delivery process. [5].

One method that can be used to identify the relationship between the main event and its causal factors is Fault Tree Analysis (FTA).[6] [7] [8]The FTA method uses a deductive approach by tracing the main event into more fundamental causal events through certain logical relationships.[6]. Through this method, the factors contributing to delivery delays can be systematically described.[9]. Next, Failure Mode and Effects Analysis (FMEA) is used to evaluate potential failures based on the severity of the impact (Severity), frequency of occurrence (Occurrence), and the ability to detect failure (Detection).[3] [4] [9]These three parameters are used to calculate the Risk Priority Number (RPN), which helps determine the priority of risks that require further attention.[10].

The simultaneous use of FTA and FMEA methods is expected to provide more focused analysis results. FTA is used to identify and describe the factors causing delivery delays, while FMEA is used to assess the risk level of the identified failure factors.[3] [10]The results of this analysis can serve as a basis for determining priorities for handling and developing improvement proposals appropriate to the company's operational conditions. Thus, the research focuses not only on identifying the causes of delays but also on considering the risk level of each failure.[5].

Based on these problems, this study aims to analyze the factors causing fleet delays in cement deliveries at PT XYZ using the Fault Tree Analysis (FTA) and Failure Mode and Effects Analysis (FMEA) methods. The study is limited to OTD data and delivery delay data for the May-August 2026 period in the CP Tuban distribution area. FTA is used to identify the factors causing delays, while FMEA is used to determine risk priorities based on RPN values.[10]The results of the analysis are used as a basis for preparing improvement proposals without discussing the implementation of the improvements directly.

II. METHOD

1. Objects, locations, and data periods

The object of this study is the delay in cement product delivery from CP Tuban, monitored by the Logistic Control Tower Unit of PT XYZ. CP Tuban was chosen because it recorded the highest delays, namely 3,420 out of 9,374 incidents throughout the region. The data used are OTD data and RCA categories for the period May-August 2026. Primary data in the form of S, O, and D assessments were collected from two questionnaires with two respondents, namely the GM and the head of the Control Tower team in November 2026.

2. Research Approach

The method used in this research is quantitative descriptive, with a case study of the cement delivery process at PT XYZ. This research was conducted to identify factors causing delivery delays using the FTA method and determine risk priorities using the FMEA method. A quantitative descriptive approach was also used in the research.[3]to describe the condition of the research object based on the data obtained. The data in this study were obtained through company OTD data, delivery delay data, and interviews with relevant parties in the Logistics Control Tower unit. The use of these data and interviews aims to determine the condition of delivery delays and identify the causal factors as the basis for FTA and FMEA analyses.

3. Data collection

This study uses primary and secondary data. Primary data were obtained through interviews and questionnaires. Interviews were conducted with 2 respondents, namely the GM and the Head of the Control Tower Logistics Unit Team to discuss and identify the factors causing delays in cement delivery, as well as

to determine the basic events used in the Fault Tree Analysis (FTA) analysis. Interview techniques were also used in the study [3] [9] [10] to obtain information that supports the analysis process. The interview results were used as a basis for compiling the FTA structure. Furthermore, questionnaires were given to 2 respondents, namely the GM and the Head of the Control Tower team to assess the severity, occurrence, and detection levels of each basic event on a scale of 1–10 in the Failure Mode and Effects Analysis (FMEA) analysis. Meanwhile, secondary data were obtained from OTD data for the period May–August 2026 as well as data on delays in CP Tuban cement delivery along with their explanations.

4. Data processing

The data processing in this study was carried out in stages using the Fault Tree Analysis (FTA) and Failure Mode and Effects Analysis (FMEA) methods. FTA was used to describe the factors causing delays in cement delivery until a basic event was obtained. Next, these factors were analyzed using FMEA by providing Severity, Occurrence, and Detection assessments. The assessment results were used to calculate the Risk Priority Number (RPN) value which became the basis for determining the factors causing delays with the highest risk priority. These results were then used to develop improvement proposals for the cement delivery process at PT XYZ.

5. FTA Method

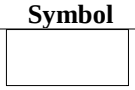
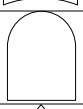
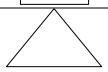
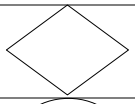
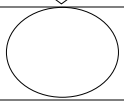
Fault Tree Analysis(FTA) is a failure analysis method that traces the causes of a major event in stages, from the top event to the most basic cause (basic event), with the help of AND and OR logic gates.[11]. The OR gate means that the event above it occurs if one of the causes occurs, while the AND gate means that all causes must occur simultaneously.

According to[10], the application of Fault Tree Analysis (FTA) in analyzing failures consists of five stages:

a. Determine the problem being studied along with the limitations of the system being analyzed.
b. Construct a fault tree diagram to illustrate the relationships between failures.
c. Determine the minimum cut set, which is the minimum combination of root causes that will result in a major failure.
d. Conduct qualitative analysis to understand the logic and structure of the relationships between causes.
e. Perform quantitative analysis to calculate the probability of failure from the numerical data of each component.

The symbols used in constructing the fault tree are presented in Table 2.

Table2FTA symbols

Symbol	Information
	*Top Event*
	*Logic Event OR*
	*Logic Event AND*
	*Transferred Event*
	*Undeveloped Event*
	*Basic Event*

Source:[10]

This study applies stages (a), (b), and (d). Top events and system boundaries are determined, a fault tree is constructed based on interview results, and the structure of relationships between causes is analyzed qualitatively. Cause priority is determined not through a minimum cut set or quantitative FTA analysis, but rather through the Risk Priority Number (RPN) value in the FMEA.

6. FMEA method

Failure Mode and Effects Analysis(FMEA) is a method for identifying and preventing the occurrence of risks or failure modes.[12]This method assesses each failure mode with three indicators, namely severity (S), occurrence (O), and detection (D).[13]. The weights of the three indicators are given based on the effects and causes of failure, and the assessment results are stated in the FMEA table.[14]. Multiplying the three produces a Risk Priority Number (RPN) which is used to determine repair priorities.[15].

The FMEA stages in this research are as follows.

1. Determining process function and failure modes. The process function analyzed was the cement delivery process from CP Tuban to its destination. Each basic event resulting from the FTA was defined as a failure mode, then potential effects (e.g., delays in arrival at the destination), potential causes, and current controls were identified based on interview results.
2. Develop assessment criteria. A scale of 1–10 is defined according to the context of cement delivery for the following three components.

- *Severity*(S): the seriousness of the impact of the failure mode on delivery delays.

Table3Severity Scale

Ranking	Severity	Description
10	Critical	Delivery Failed
9	Dangerous	Delay > 2 days
8	Very high	Delay > 1 day
7	Tall	Delay > 18-23 hours
6	Medium-High	Delay > 15-17 hours
5	Currently	Delay > 12-14 hours
4	Low-Medium	Delay > 9-11 hours
3	Low	Delay > 6-8 hours
2	Very Low	Delay > 2-4 hours
1	There isn't any	Delay <1 hour

- *Occurrence*(O): how often the failure cause occurs.

Table4Occurrence Scale

Ranking	Occurrence	Information
9-10	Very high	Happened more than 60 times
7-8	Tall	31–60 times
4-6	Currently	Occurs 11–30 times
2-3	Low	Occurs 1–10 times
1	Very Low	Not happened for 3 months

- *Detection*(D): current control capabilities detect the cause of failure before it has an impact.

Table5Detection Scale

Ranking	Detection	Information
10	Very Low	Failure cannot be detected before delay occurs.
9	Low	Failures almost always go undetected before delays occur.
8	Low-Medium	Failure is very difficult to detect even after inspection.
7	Currently	Failures are difficult to detect and require further investigation.
6	Medium-High	Failures are often discovered during the delivery process.
5	High enough	Failures can be discovered through routine monitoring, but are not always detected early.
4	Tall	Failures are fairly easy to spot by monitoring the delivery process.
3	Very high	Failures are easily detected through pre-departure inspections.
2	The tallest	Failures are almost always detected through routine pre-departure inspections.
1	Optimal	Failures are always detected before the fleet is dispatched.

3. Assessing S, O and D. The assessment was conducted with 2 respondents and through a questionnaire to the GM and the Head of the Control Tower Team based on Table 3-5. The O value was compared with the Delay frequency data for the period May–August 2026. The final value for each component was taken from the average of the respondents' answers.
4. Calculating RPN. The RPN value, namely the risk priority number, is calculated using the equation: $RPN = S \times O \times D$
5. Prioritize. The RPNs of all failure modes (basic events) are ranked from highest to lowest to

determine the most urgent cause of delay. Failure modes with a high S are still considered even if their RPNs are low.

6. Develop improvement proposals. Proposals are compiled for priority categories and failure modes based on interview results.

III. RESULTS AND DISCUSSION

1. Data Collection on CP Tuban Delays

The following is data on delays in CP Tuban cement deliveries from May to August 2026. During this period, 3,420 delays were recorded, with 892 incidents in May, 815 incidents in June, 696 incidents in July, and 1,017 incidents in August. Based on the delay data and their causes, there are nine main categories of causes for delivery delays: Drivers Not Shifting APK, Stock Levels, Long Parking, Releases, Permits, Overnight, Damaged, Accidents, and Pallets. The number of incidents in each category is presented in Table 6.

Table6Data on the Cause of Delayed Delivery of CP Tuban

Category	Reason	May	June	July	August	Total
Warehouse Category	Stock Level	360	304	253	400	1317
	Release	157	159	257	354	927
	Stay	2	1	2	6	11
	Pallet	0	15	4	0	19
Driver Category	Driver does not slide APK	46	63	34	20	163
	Long parking	322	253	125	215	915
	Permission	3	5	3	13	24
	Fleet Damage	2	15	17	9	43
Accident		0	0	1	0	1
Total		892	815	696	1017	3420

Source: Data of PT XYZ

Based on Table 6, it can be seen that the warehouse category is the cause of the most delays, namely 2,274 incidents, followed by the driver category with 1,145 incidents, and finally an accident with 1 incident. In the warehouse category, the most common cause is Stock Level with 1,317 incidents, followed by Release with 927 incidents, then Pallet with 19 incidents, and finally Overnight with 11 incidents. In the driver category, the most common cause is Long Parking with 915 incidents, followed by Drivers Not Shifting APK with 163 incidents, then Fleet Damage with 43 incidents, and finally Permit with 24 incidents.

2. Process Failure Identification Using Method (FTA)

The fault tree was constructed in stages by breaking down the top events causing delivery delays at CP Tuban into three causal categories: warehouse constraints, driver constraints, and accidents. Each category was first structured separately, from intermediate events to basic events, along with their corresponding logic gates, to clearly understand the cause-and-effect relationships within each category before being combined into a complete fault tree.

In the warehouse category, warehouse constraints consist of two intermediate events: Inap and Rilisan, which are connected by an OR gate. This means that delays due to warehouse constraints can occur if either of these two events occurs. Inap is caused by excessively long unloading queues and long unloading queues, while Rilisan is caused by empty warehouse pallets and stock levels. Thus, the warehouse category has four basic events. The fault tree for the warehouse category can be seen in Figure 2.

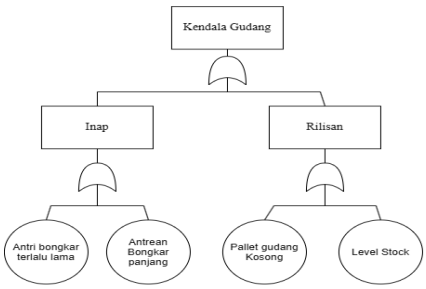


Fig. 1. FTA Warehouse Constraints

In the driver category, driver constraints consist of three intermediate events: prolonged parking, driver failure to shift APK, and fleet damage, which are linked to the OR gate. Long parking is caused by fleet damage and driver prolonged rest, which are linked to the OR gate. Fleet damage occurs when the driver fails to perform equipment checklists or does not comply with maintenance schedules, so both are linked to the OR gate. Meanwhile, driver failure to shift APK is caused by problematic device drivers, APK driver errors, and driver neglect, which are linked to the OR gate. Overall, the driver category has seven basic events. The driver category fault tree can be seen in Figure 3.

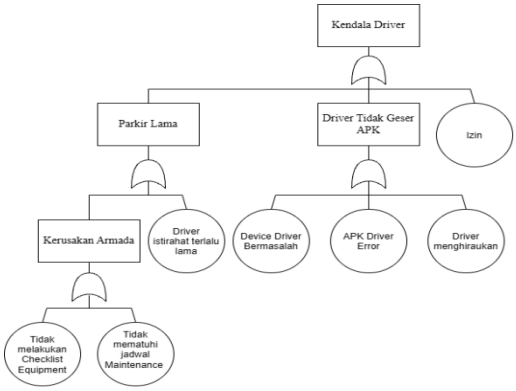


Fig. 2. FTA Driver Constraints

In the accident category, accidents are caused by three basic events connected by an OR gate: driver drowsiness, driver failure to follow the recommended route, and hazardous terrain. These three factors are independent of each other, so the occurrence of just one of these causes is sufficient to trigger an accident, resulting in delivery delays. The fault tree for the accident category can be seen in Figure 4.

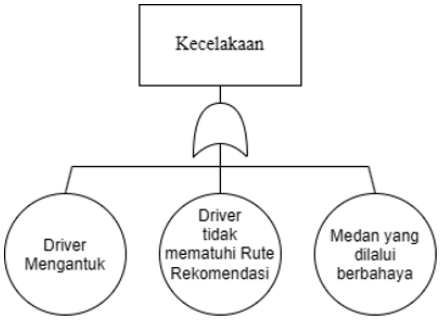


Fig. 3. FTA Accident

After the three categories were compiled, the fault trees for each category were combined into a single fault tree, complete with the top event of the delivery delay at CP Tuban. This combined fault tree illustrates all causes of the delay in a hierarchical manner, and the 14 basic events within it serve as the basis for the assessment in the FMEA phase. The combined fault tree can be seen in Figure 5.

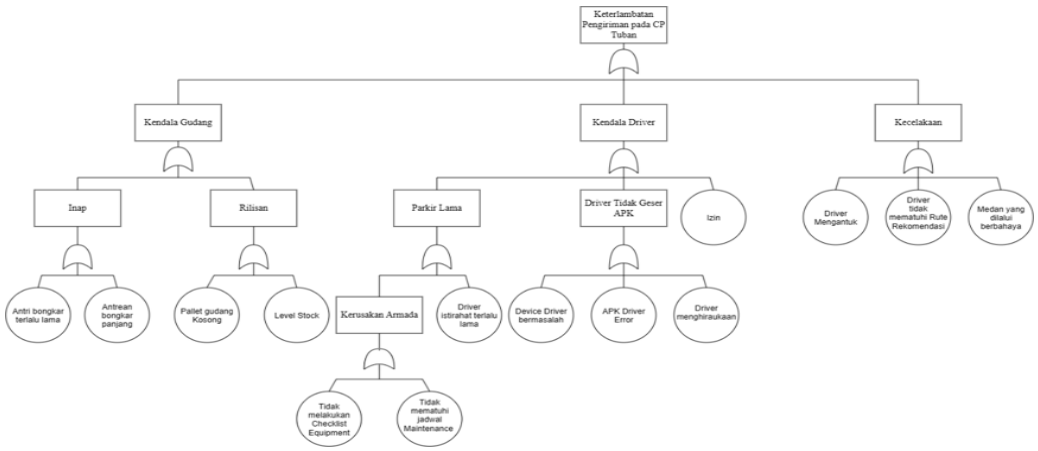


Fig. 4 FTA Delayed Delivery at CP Tuban

Based on the fault tree in Figure 5, the top events causing delivery delays at CP Tuban were caused by three categories: warehouse constraints, driver constraints, and accidents. These three categories were broken down to yield 14 basic events, consisting of four warehouse constraints, seven driver constraints, and three accidents. The results of the basic event determination are presented in Table 7.

Table7Basic Event

No	Intermediate Event	Basic Event
1	Stay	Long unloading queue
		The queue for unloading is too long
2	Release	Empty warehouse pallets
		Stock level
3	Driver Constraints	Permission
4	Old Parking	Driver rests too long
5	Driver Does Not Swipe APK	Device Driver problem
		APK Driver Error
		The driver ignored it
6	Fleet Damage	Not doing the Equipment Checklist
		Not complying with the maintenance schedule
7	Accident	Drowsy Driver
		Driver does not comply with Recommended Route
		The terrain is dangerous

The FTA results only map the causes of delays and do not indicate which causes require the most priority. Therefore, the 14 basic events in Table 7 are designated as failure modes and assessed in the FMEA phase based on severity, occurrence, and detection values.

3. FMEA Assessment Results

FMEA assessment was conducted on 14 failure modes derived from basic events from FTA results in Table 7. Severity, occurrence, and detection assessments were obtained through questionnaires and interviews with the GM and Control Tower team leaders based on the scale criteria in Tables 3 to 5. The final value of each component was determined from the average of the respondents' answers. The occurrence value was also compared with the RCA frequency data in Table 6 to ensure the assessment was in accordance with field conditions.

Table8FMEA Assessment

Failure Mode	Potential Effects	Current Control	S	O	D	RPN
Long unloading queue	The fleet is waiting for its turn to unload so the time in the warehouse increases.	Monitoring fleet queues and coordinating with warehouse staff.	6	2	4	48

The queue for unloading is too long	Unloading waiting time exceeds the limit, fleet is stuck in the warehouse (staying overnight)	Monitoring of unloading times and coordination regarding unloading delays.	7	2	6	84
Empty warehouse pallets	Unloading schedule released late, fleet departure delayed	Checking pallet availability and coordinating with the warehouse.	7	4	6	168
Stock level	Unloading schedule released late, fleet departure delayed	Monitoring warehouse stock levels through MB Excellent	8	10	3	240
Driver rests too long	Unloading schedule released late, fleet departure delayed	Monitoring fleet position and activity through a monitoring system.	6	9	6	324
Device driver problem	Unloading confirmation cannot be done, delivery status is not updated	Coordination with driver.	5	4	4	80
APK driver error	Unload confirmation in APK failed, delivery status not updated	Application status monitoring	5	4	4	80
The driver ignored it	Confirmation of unloading was not done, delivery status was not updated.	Providing reminders and reconfirmations to drivers.	6	9	7	378
Permission	Driver not operating, delivery delayed	Coordination regarding the availability of replacement drivers.	5	4	2	40
Not doing an equipment checklist	The condition of the fleet is unknown before departure, there is a risk of damage during the trip.	Fleet condition check before departure.	8	7	7	392
Not adhering to maintenance schedules	Fleet maintenance not according to schedule, risk of damage on the way	Maintenance schedule monitoring	8	8	7	448

Sleepy driver	Risk of accidents, trip interruptions and delays	Break time settings.	9	2	8	144
Driver did not comply with the recommended route	Increased travel time, risk of accidents	Monitoring fleet position and route compliance.	7	2	5	70
The terrain is dangerous	Travel slows or stops, risk of accident	Monitoring route conditions and providing directions to drivers.	8	2	6	96

Based on Table 8, the failure mode with the highest RPN is Not complying with the maintenance schedule at 448, which is influenced by high severity (8) and occurrence (8) values. The next ranking is occupied by Not carrying out equipment checklists at 392, Driver ignoring at 378, and Driver taking too long breaks at 324. These four failure modes were determined as repair priorities because there was a clear difference to the fifth ranking, namely Stock level at 240, with a difference of 84.

4. Analysis and Discussion

Based on Figure 5 and Table 7, the FTA results show that the top events causing delivery delays at CP Tuban were caused by 14 basic events divided into three groups. Warehouse constraints had four basic events: long unloading queues, excessively long unloading queues, empty warehouse pallets, and stock levels. Driver constraints had seven basic events: drivers taking too long breaks, driver device problems, driver APK errors, drivers ignoring permission, not completing equipment checklists, and not adhering to maintenance schedules. Accidents had three basic events: drivers being sleepy, drivers not adhering to recommended routes, and dangerous terrain.

All of these basic events are connected by OR gates, so each can cause a delay without requiring any other event. This also applies to fleet breakdowns, such as failing to perform equipment checklists and failing to adhere to maintenance schedules. Fleet breakdowns can occur if either occurs.

The FTA results were then assessed using FMEA. Based on Table 8, the RPN values ranged from 48 to 448. The four failure modes with the highest RPN were not adhering to the maintenance schedule at 448, not performing the equipment checklist at 392, driver ignoring at 378, and driver taking too long breaks at 324. All four came from the driver constraint group, while the accident group had a low RPN due to its low frequency of occurrence. The stock level from the warehouse constraint group was ranked fifth with an RPN of 240. Based on these results, proposed improvements can be focused on not adhering to the maintenance schedule, not performing the equipment checklist, driver ignoring, and driver taking too long breaks because their RPN values were far above the fifth rank (a difference of 84), and each could directly cause delays according to the OR gate structure in the FTA.

5. Proposed Improvements to Priority Failure Mode

The proposed improvements were prepared using the 5W+1H method as per the research conducted by[10], namely what (what is being repaired), why (why it needs to be repaired), where (where), when (when), who (who is responsible), and how (how). The proposal focuses on four failure modes with the highest RPN, namely not adhering to the maintenance schedule, not carrying out the equipment checklist, and driver neglect. The results of the compilation are presented in Table 9.

Table9Proposed Improvements with the 5W+1H Method

Failure Mode	What	Why	Where	When	Who	How
Not adhering to maintena	Create automatic maintenance schedule	The highest RPN (448) with an occurrence	Control Tower monitorin g system	Before the maintenan ce schedule	Head of Control Tower Team, IT	Add automatic reminders to the monitoring system when

nce schedule (RPN 448)	reminders and record fleet maintenance realization.	value of 8 and detection of 7, while the current control is only monitoring the maintenance schedule.	and fleet workshop	is due and before the fleet is commissioned	Team, maintenance department, and drivers	maintenance schedules are approaching due date, then the Control Tower ensures that maintenance is realized and records it before the fleet is dispatched.
Not performing equipment checklist (RPN 392)	Requires filling out a digital equipment checklist before the fleet departs	Severity 8, occurrence 7, and detection 7 indicate that fleet damage is at risk of occurring en route and is difficult to detect, while the current control is only a fleet condition check before departure.	CP Tuban driver application and departure area	Before the fleet departs from CP Tuban	Driver and Control Tower	Make the equipment checklist a departure requirement on the APK, then the Control Tower verifies the checklist results before the fleet is allowed to depart.
Driver ignores (RPN 378)	Provide reminders and confirmation to drivers to confirm according to reporting procedures.	Confirmation in APK was not done (163 occurrences), occurrence 9, and detection 7 indicate difficult to detect.	Driver and Control Tower applications	After the dismantling process is complete	Control Tower and driver	Adding automatic confirmation reminders to APKs, having Control Tower reconfirm if not already done, and logging drivers who repeatedly fail to confirm for evaluation
Driver rests too long (RPN 324)	Create an automatic notification system and record driver parking or rest times.	Old parking reached 915 incidents and an occurrence value of 9, while the current control is only monitoring the fleet position.	Control Tower monitoring system and driver parking or rest area	During the trip, when the parking time approaches the 2 hour tolerance limit	Control Tower Team Leader, IT Team, and Driver	Add notification to the monitoring system when parking exceeds 2 hours, then Control Tower contacts the driver and records the parking duration for evaluation.

Based on Table 9, proposed improvements are compiled for the four failure modes with the highest RPN. For non-compliance with maintenance schedules, improvements focus on automatic schedule reminders and recording maintenance realization so that fleet maintenance is realized before the fleet is deployed. For failure to perform equipment checklists, improvements focus on digital checklists that must be completed and verified by the Control Tower before the fleet departs. For drivers who ignore them, improvements focus

on automatic confirmation reminders in the APK and reconfirmation by the Control Tower. For drivers who take too long breaks, improvements focus on automatic notifications and recording parking time so that the Control Tower can contact the driver before the 2-hour tolerance limit is exceeded. These four proposals are preventative and early detection in nature, so they are expected to reduce the occurrence and detection values, which are the main drivers of RPN. By reducing these two values, the RPN for all four failure modes is expected to decrease and delays in CP Tuban delivery can be reduced.

IV. CONCLUSION

Based on the results of research on delays in CP Tuban cement deliveries for the May–August 2026 period, the following conclusions were obtained.

1. The causes of delivery delays were identified through FTA. The delays were caused by 14 basic events divided into three groups: four warehouse-related events, seven driver-related events, and three accident-related events. All basic events were connected by OR gates, so each could directly cause a delay.
2. The cause priorities were determined through FMEA. The RPN values ranged from 48 to 448. The four failure modes with the highest RPNs were not adhering to the maintenance schedule at 448, not performing the equipment checklist at 392, the driver ignoring it at 378, and the driver taking too long a break at 324. These four were determined as priority repairs because they were far above the fifth rank, which was the stock level at 240, with a difference of 84.
3. The improvement proposals are prepared using the 5W+1H method for the four priority failure modes, namely:

- automatic maintenance schedule reminders and fleet maintenance realization recording.
- digital equipment checklist that must be filled out before the fleet departs.
- automatic confirmation reminder on driver app.
- automatic notification and recording of driver parking or rest time.

4. FTA plays a role in mapping all causes of delays, while FMEA determines the causes that need to be prioritized for repair.

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