Risk Analysis of Delayed Departure of Cement Trucks and Proposed Improvements Using Fishbone Diagram and FMEA

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Abstract.
Delays in truck departures can disrupt distribution processes and affect a company's operational targets. This study aims to identify the causes of cement truck departure delays on the Rembang route at PT Semen Indonesia Logistik and to determine improvement priorities using a Fishbone Diagram and Failure Mode and Effects Analysis (FMEA). A descriptive approach with qualitative and quantitative analysis was applied, using operational departure data for May–July 2026, observations, and assessments by two experts. Of 265 departures, 41 were delayed (15.5%). The Fishbone Diagram grouped the causes into five categories: Man, Method/Environment, Machine, Operational, and Administration. The FMEA showed that receiving warehouse stock constraints (level stock) had the highest Risk Priority Number (RPN) of 392 (S = 8, O = 7, D = 7), followed by prolonged parking time (378) and vehicle breakdowns (RSK) (270). Level stock and prolonged parking were the main improvement priorities, together accounting for 32 of 41 delays (78%), while vehicle breakdowns remain under monitoring because of their highest severity.
Keywords: *Fishbone Diagram, FMEA, Departure Delay, RPN and Cement Truck.*

I. INTRODUCTION

Distribution activities are a crucial part of the logistics process because they are related to the timely delivery of goods from their point of origin to their destination. Delays in the distribution process can disrupt operational smoothness and impact a company's service quality. Hersanto et al. (2023) explain that speed and accuracy of delivery are crucial factors in logistics services, while delivery constraints can reduce the quality of service received by consumers. Delivery reliability also impacts customer satisfaction and company performance (Al-Shboul, 2017), and on-time delivery is a primary goal of a logistics system (Niemi et al., 2020).

Delayed departures impact operational and financial aspects. Operationally, delays reduce on-time departure rates, shift delivery schedules, and decrease fleet utilization. Financially, additional waiting time can incur costs, such as demurrage and unproductive fleet and driver costs, and potentially lead to penalties from customers (Bushuev, 2018). The extent of these costs depends on each company's policies.

PT Semen Indonesia Logistik carries out logistics activities, including cement delivery using a fleet of trucks. Based on observations during internships in the Operational Excellence Department, delays in the departure of cement trucks bound for Rembang were observed. Data from May–July 2026 showed 41 delays out of 265 departures (15.5%), resulting in an on-time departure rate of 84.5% (224 out of 265 departures). The highest percentage of delays occurred in May 2026 (19.1%), followed by July (16.7%) and June (10.3%).

The operational work practice records show five indications of causes of delays, namely the driver did not shift the APK (the driver did not update the trip status on the operational application according to procedure), long parking (the truck waited in the parking area beyond the planned time), stock level (the unloading warehouse was full so that the operational process was hampered), RSK/damaged (damage or disruption to the fleet), and release (issuance of release documents or delivery notes before delivery). These indications need to be investigated further to determine the cause of the delay in delivery to Rembang.

Fishbone diagrams are used to identify and group possible causes of a problem, while Failure Mode and Effects Analysis (FMEA) is used to determine handling priorities through assessments of Severity (S), Occurrence (O), and Detection (D) which are calculated into a Risk Priority Number (RPN). FMEA has been used in cases of late deliveries (Hapiuzin et al., 2022; Fatah et al., 2025) and, together with Fishbone diagrams, in cases of failure (Khairansyah et al., 2024). However, its application to the delay in the departure of cement trucks to Rembang requires considering the characteristics of cement distribution, especially the loading and departure queues. Therefore, a combination of the two is applied so that causes are systematically identified and handling priorities are determined based on the risk level.

This study aims to (1) determine the level of delay in the departure of cement trucks to Rembang in the period May–July 2026, (2) identify the causal factors using Fishbone Diagram, (3) assess the risk level and priority of handling each factor based on RPN in FMEA, and (4) prepare improvement proposals that are appropriate to the company's operational conditions. The results are expected to be the basis for determining improvement priorities for the company as well as a reference for similar research on logistics and distribution processes.

II. LITERATURE REVIEW

Logistics and Distribution

Logistics is the activity of managing and moving goods from their point of origin to their destination, encompassing transportation, storage, handling, and control of the flow of goods. Distribution is the stage of delivering goods to recipients, making timeliness one of the most readily perceived performance measures by service users. Hersanto et al. (2023) explain that speed and accuracy of delivery are critical factors in logistics services. Because the stages are sequential, delays in one stage can spread to the next; Amalia et al. (2025) identified road conditions, weather, and fleet readiness as factors influencing the smooth distribution of food aid rice.

Truck Delay

Truck departure delays occur when a fleet departs past its scheduled time. Departure is the starting point of delivery, so delays at this point can shift the entire delivery chain and reduce on-time delivery. Delays can stem from vehicle readiness, goods availability, completeness of documents, implementation of operational procedures, and other factors before the fleet leaves the location. Previous research indicates various causes: Hapiuzin et al. (2022) identified unsafe fleet conditions, detours, and excessive working hours as priority factors for improvement; Amalia et al. (2025) identified road access, weather, and fleet readiness; Fatah et al. (2025) identified driver behavior and fleet damage as causes of high RPN. Somadi (2020) and Rollandiaz and Iskandar (2024) evaluated delivery delays using Six Sigma and Lean Six Sigma approaches. Therefore, causes need to be systematically identified before improvements are determined.

Fishbone Diagram

A fishbone diagram, also called a cause-and-effect diagram or Ishikawa diagram, is an analytical tool for identifying and grouping possible causes of a problem. The main problem is placed at the head of the fish, while the causes are placed along the branches leading to it. Causes can be grouped into categories appropriate to the research object, such as humans, methods, machines or equipment, materials, measurements, and the environment. This grouping helps the search for causes become more focused, as each category provides a different perspective on the same problem.

Budiyani and Hartini (2025) used a Fishbone Diagram to identify the causes of delays in the distribution of bulk cargo from ships to warehouses. Amalia et al. (2025) also used it to trace the factors causing delays in the distribution of food aid rice. Both studies demonstrated that the Fishbone Diagram can systematically identify causal factors in various cases of distribution delays. Its limitation is that this diagram only maps the causes and does not indicate which causes need to be prioritized most. This limitation encourages the use of risk assessment methods such as FMEA.

Failure Mode and Effects Analysis (FMEA)

Failure Mode and Effects Analysis (FMEA) is an analytical method for identifying potential failure modes, their impacts (effects), and causes (causes). FMEA is also used to prioritize treatment based on risk levels. Each potential failure is assessed using three parameters: severity of impact, likelihood of occurrence, and detectability. This approach ensures that treatment is not applied evenly to all problems, but rather focuses on failures with the greatest risk.

Hapiuzin et al. (2022) applied FMEA to a study of late delivery of goods to determine factors that need to be prioritized for improvement. Fatah et al. (2025) used FMEA on a product delivery process and recommended improvements for potential failures with an RPN above 100. Khairansyah et al. (2024) applied FMEA to assess failure risks, then used a Fishbone Diagram to trace the causes of failures with the highest RPN. Thus, FMEA can be used for both cases of late delivery and failures in general.

Severity, Occurrence, and Detection

FMEA assessment uses three parameters: Severity (S), Occurrence (O), and Detection (D) (Pangestuti et al., 2022). Severity indicates the severity of the impact if a failure occurs. Occurrence indicates the likelihood or frequency of the cause of the failure occurring. Detection indicates the ability of existing controls to detect the failure or its cause before its impact occurs. For Detection, the more difficult the failure is to detect, the higher the value, so the direction of the assessment is the opposite of detection ability.

To ensure consistency and comparability between causes, each parameter is assessed using an ordinal scale of 1 to 10 with clear criteria. This 1–10 scale is commonly used in FMEAs and refers to the guidelines of Nelfiyanti et al. (2024) and Muttaqin and Kusuma (2018). The criteria in the following table reflect an adjustment of the scale to the context of cement truck delays, as explained in the last column of each table.

Table 1. Severity (S) assessment criteria

Rank	Criteria	Information	Application to Truck Departure
10	Dangerous without warning	Failure to produce very dangerous effects	Disturbances cause accidents or serious damage to cargo or fleets without any prior warning.
9	Dangerous with warning	Failure to produce harmful effects	The disturbance endangers safety or cargo, but there are early signs (e.g. visible damage to the fleet before departure).
8	Very high	The system is not operating	The departure process is completely stopped until the problem is resolved (for example, the destination warehouse is full so the truck is held up).
7	Tall	The system is operational but cannot be fully operational	Departures continued, but the schedule shifted significantly and operations could not be fully operational.
6	Currently	Failure to provide an effect resulting in loss of function	One important function was missing so some trips had to be rescheduled.
5	Low	Partial system function degradation	Monitoring or administrative functions are reduced (e.g. inaccurate trip status or short-delayed documents), the fleet can still depart.
4	Very low	Minor effect on system performance	A minor delay that can still be caught up during the trip.
3	Small	Little impact on system performance	Has little impact on punctuality without changing arrival schedule.
2	Very small	Negligible effect on system performance	The effect is negligible; departure remains on schedule.
1	No effect	No effect	Does not affect truck departure.

Source: Adapted from Nelfiyanti et al. (2024)

Table 2. Occurrence (O) assessment criteria

Rank	Criteria	Failure Rate	Application to Truck Departure
10	Failure is almost inevitable	> 1 of 2	Almost every departure is late due to this cause.
9	Very high	1 of 3	Occurs in about a third of departures.
8	High: often causes failure in previous processes	1 of 8	Often repeated on operational days.
7	Tall	1 of 20	Quite often; repeated every month of observation.
6	Medium: fails occasionally but not a large amount	1 of 80	It happens sometimes and not in large numbers.
5	Currently	1 in 400	Occurred occasionally during the observation period.
4	Currently	1 in 2,000	Rarely happening.
3	Low: isolated failure on identical process	1 in 15,000	Very rare; isolated cases in the same process.

2	Very low: only isolated incidents	1 in 150,000	Just an isolated incident.
1	Almost impossible	< 1 in 1,500,000	It almost never happens on truck departures.

Source: Adapted from Muttaqin and Kusuma (2018)

Table 3. Detection assessment criteria (D)

Rank	Criteria	Information	Application to Truck Departure
10	Not detected	There is no systematic prevention or monitoring (detection < 1%)	There was no monitoring; the delay was only discovered after the truck was late in departing.
9	Very little chance	No prevention, surveillance is rare (detects 10% after occurrence)	Surveillance is rare; most cases only become apparent after the fact.
8	Little chance	There is no prevention, there is monitoring but it is not guaranteed (detecting 50% after it occurs)	There is monitoring (for example by the Control Tower), but it does not guarantee that every incident is caught.
7	Very low	There is no prevention, but there is systemic monitoring (detects 90% after it occurs)	There is systemic monitoring, but it only catches incidents after they happen.
6	Low	Very little chance of detecting before it happens (10%)	Early warning is very limited before delays occur.
5	Currently	Little chance of detecting before it happens (30%)	A small number of causes can be identified before the scheduled departure.
4	High enough	Great chance of detecting before it happens (50%)	Pre-departure checks catch about half of the causes.
3	Tall	High probability of detecting before it happens (70%)	Screening and monitoring catch most causes early.
2	Very high	Very high probability of detecting before it happens (85%)	Automatic notifications provide early warning in almost all cases.
1	Almost certainly	Definitely detected before it happens (100%)	Control ensures the cause is detected before departure.

Source: Adapted from Muttaqin and Kusuma (2018)

Risk Priority Number (RPN)

The Risk Priority Number (RPN) is a value used in FMEA to help determine risk management priorities. The RPN value is obtained by multiplying Severity, Occurrence, and Detection (Muttaqin & Kusuma, 2018; Nelfiyanti et al., 2024):

$$\mathrm{RPN}_i = S_i \times O_i \times D_i$$

where is the Risk Priority Number value of the i-th potential failure; is Severity; is Occurrence; and is Detection.$\mathrm{RPN}_i S_i O_i D_i$

With a scale of 1–10 for each parameter, the RPN value ranges from 1 to 1,000; the higher the RPN, the higher the priority for handling (Muttaqin & Kusuma, 2018; Nelfiyanti et al., 2024).

RPN has limitations because different combinations of S, O, and D can produce the same RPN, even though the level of danger is different. A high-severity failure that occurs infrequently and is easy to detect can have an RPN equivalent to a low-severity failure that occurs frequently and is difficult to detect, so serious failures can be overlooked. Nevertheless, RPN remains widely used because it is simple and easy to implement (Muttaqin & Kusuma, 2018; Nelfiyanti et al., 2024), so repair decisions need to consider both RPN and Severity.

Relationship between Fishbone Diagram and FMEA

Fishbone diagrams and FMEAs have different functions, but they complement each other. A Fishbone diagram maps and groups possible causes of a problem, but it doesn't indicate which causes need to be addressed first, as all causes are given equal weight. An FMEA assesses risk levels and determines priorities, but requires a list of potential failures and their causes as a basis for assessment. Thus, a Fishbone diagram answers the question "what are the possible causes of the problem?" while an FMEA answers the question "which causes are the riskiest and need to be addressed first."

Previous research shows that both methods can be sequenced in two ways: Fishbone Diagram first, then FMEA to determine priorities (Hapiuzin et al., 2022), or FMEA first, then Fishbone Diagram to trace the causes of failures with the highest RPN (Khairansyah et al., 2024).

In cases of delay, the possible causes are diverse and the dominant one is unknown. Therefore, the logical sequence is to identify the causes using a Fishbone Diagram and then assess them using FMEA. The list of causes from the Fishbone Diagram is converted into potential failures, assessed as S, O, and D, calculated into the RPN, and the results form the basis for proposed improvements to the highest-risk causes.

III. RESEARCH METHODS

Types and Approaches of Research

This research uses a descriptive approach with qualitative and quantitative analysis. The qualitative approach explores causal factors through observation and interviews, while the quantitative approach assesses risk levels using a Fishbone Diagram (FMEA). A Fishbone Diagram identifies the root cause of a problem, while a FMEA determines improvement priorities based on the RPN.

Objects, Locations, and Data Sources

The research was conducted at PT Semen Indonesia Logistik on the departure process of cement trucks bound for Rembang. The object of the research was the delay in truck departures and their causal factors, which were selected based on the findings of practical work in the form of departures that exceeded the company's schedule. Secondary data came from operational records for the period May–July 2026 (number of departures, number of delays, and root cause analysis/RCA) obtained through documentation. Primary data was obtained through observation of operational processes as well as interviews and respondent assessments to confirm the causes of delays and provide S, O, and D values based on Tables 1–3.

Research Respondents

The assessment of S, O, and D is subjective and therefore conducted through expert judgment with purposive sampling, based on the following criteria: (1) directly involved in the management or control of the departure process of trucks to Rembang, (2) experienced in the field, and (3) willing to provide an assessment. Respondents were the Head of the Operational Excellence Department, who evaluates the punctuality of departures, and the Head of the Control Tower Department, who monitors fleet movements. Both assessed independently based on Tables 1–3, then the values were combined with an arithmetic mean (equal weight) rounded to the nearest whole number (0.5 rounded up) to fit a scale of 1–10, with the following formula.

$$X_i = \text{round}\left(\frac{1}{n}\sum_{r=1}^{n} X_{ir}\right)$$

where X is the parameter being assessed (Severity, Occurrence, or Detection), is the final value of the parameter at the i-th potential failure, is the value of the r-th respondent, and n is the number of respondents (n = 2).$X_i X_{ir}$

Data Analysis Techniques

The research flow is shown in Figure 1. The stages of problem identification, literature study, and data collection have been described previously, while data analysis was carried out through the following eight stages.

1. Recapitulation and percentage of lateness. Departure data for May–July 2026 was summarized monthly, then the monthly and overall percentage of lateness was calculated as the number of late departures divided by the total number of departures, multiplied by 100%.
2. Identify the factors causing delays. RCA records are compared with observation and interview results to obtain a list of relevant causal factors, noting the number of delays for each factor () used in prioritization.k_i
3. Analysis using a Fishbone Diagram. Causal factors are grouped according to the categories of humans (man), methods (method), machines or equipment (machine), materials, measurements (measurement),

and environment (environment) according to the research results, with each factor being placed based on evidence from data, observations, and interviews.

4. Identify potential failures using FMEA. Based on the Fishbone Diagram, each causal factor is formulated as a potential failure mode, then its impact (effect) on the truck departure process is analyzed.
5. Severity, Occurrence, and Detection Assessment. Each potential failure is assessed by two expert respondents using Tables 1–3, and the final score is obtained using the formula in the Research Respondents sub-chapter.
6. Risk Priority Number (RPN) calculation. RPN is calculated by multiplying the final values of Severity, Occurrence, and Detection (RPN = S × O × D). The Severity level is still considered in determining corrective actions.
7. Risk prioritization. Potential failures are ranked from highest to lowest RPN. The contribution of each factor to the total delay is calculated using the following formula, then accumulated to determine the dominant factor (Pareto principle).

$$C_i = \frac{k_i}{T} \times 100\%$$

where is the percentage contribution of the i-th factor, is the number of delay events due to the i-th factor, and T is the total number of delay events. The factor with the highest RPN becomes the top priority, while the factor with the highest Severity remains monitored even though its RPN is lower.$C_i k_i$

8. Improvement proposals. Priority factors form the basis for improvement proposals, which are compiled in a 5W+1H matrix (what, why, where, when, who, how) based on the company's operational conditions.

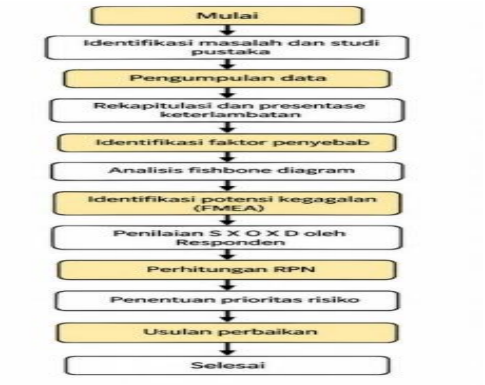


Fig. 1. Research flowchart

IV. DISCUSSION

Analysis of Delays in Departure of Cement Trucks

Based on operational data from PT Semen Indonesia Logistik for the May–July 2026 period, 265 cement truck departures to Rembang were recorded, with 41 delays (15.5%). This inaccuracy impacts the reliability of the distribution channel, as departure times are the starting point of the delivery chain. The monthly delay percentage peaked in May 2026 (19.1%), decreased in June 2026 (10.3%), and increased again in July 2026 (16.7%). The decrease in June indicates a temporary improvement, but the increase in July indicates that the risk of delays is not yet consistently and systematically controlled.

Identifying Causal Factors Using Fishbone Diagram

To map the root causes of the problem in detail, an analysis was conducted using a Fishbone Diagram (Ishikawa Diagram). The results of the Root Cause Analysis (RCA) records, field observations, and interviews with operational personnel grouped the causes of delays into five main categories:

1. Human: Drivers do not update the trip status on the logistics operational application in a disciplined manner, so that Control Tower officers experience difficulties in monitoring the position and readiness of the fleet in real-time.

2. Method/Environment: Excessive waiting times in the parking area before the fleet departs. These long waits are caused by preparation queues and a lack of a parking time limit monitoring system.
3. Machine: The occurrence of technical problems or fleet damage (RSK) which causes the vehicle to be unroadworthy until repairs are completed.
4. Operational: The condition of the unloading warehouse at the destination location (Rembang) is full (high stock level) or not ready to receive unloading, so that trucks that are ready to leave are forced to be held back.
5. Administration: Delaysin the issuance of release documents or delivery waybills by the administration before the fleet is allowed to depart.

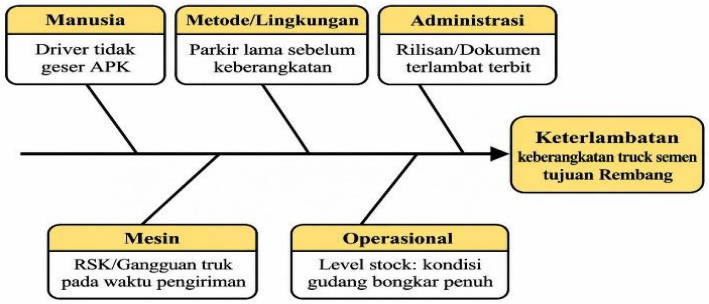


Fig. 2. Fishbone Diagram of the causes of delays in the departure of cement trucks to Rembang

Risk Analysis Using Failure Mode and Effects Analysis (FMEA)

FMEA analysis is conducted by assessing Severity (S/impact severity), Occurrence (O/frequency of occurrence), and Detection (D/system detection capability) by two experts (Head of Operational Excellence and Head of Control Tower) on a scale of 1–10. The RPN value is calculated using the formula:

$$\mathrm{RPN}_i = S_i \times O_i \times D_i$$

Table 4. Results of FMEA assessment recapitulation and RPN calculations

No	Fishbone Category	Potential Failure (Failure Mode)	Impact (Effect)	S	O	D	RPN
1	Operational	Stock level: warehouse is full or not ready to receive	Trucks waiting and further processing is hampered	8	7	7	392
2	Method/Environment	Parking too long before departure	Departure schedule shifted	7	6	9	378
3	Machine	RSK/truck damage or vehicle breakdown	The truck is not roadworthy until the problem is addressed.	9	5	6	270
4	Man	Driver does not shift/update status in APK	Travel status is inaccurate so monitoring and follow-up is delayed	5	6	7	210
5	Administration	Release or release document is late in publication	The truck cannot be dispatched even though other preparations are fulfilled.	5	5	5	125

Discussion of FMEA Results:

1. Unloading Warehouse Stock Level (RPN = 392, Rank 1): This factor has the highest RPN. Severity is 8 because a full destination warehouse halted the delivery process, Occurrence is 7 (19 out of 41 delay events), and Detection is 7 because stock quota monitoring was not integrated in real-time before fleet assignment.
2. Parking Too Long Before Departure (RPN = 378, Rank 2): The RPN is only 14 points off the top spot and this factor contributed to 13 delays. Detection = 9 (the worst of all factors) indicates that parking duration is barely monitored by the control system, resulting in delays only being noticed after they occur.
3. Fleet/RSK Damage (RPN = 270, Rank 3): The frequency is relatively rare (O = 5; 1 incident during this period), but the Severity is highest (S = 9) because the sudden damage disrupts the departure flow. Therefore, the RSK remains closely monitored through preventive maintenance.
4. Driver Does Not Shift APK Status (RPN = 210, Rank 4) and Late Release Document (RPN = 125, Rank 5): Both are of Medium Severity (S = 5) because they do not stop the physical operation of the fleet, but instead cause inaccurate monitoring data and a short administrative lag.

Integration of Fishbone Diagram and FMEA

The FMEA results are linked back to each branch of the Fishbone Diagram (Figure 2) so that the cause mapping and risk ranking can be read as a single analysis chain. These relationships are presented in Table 5.

Table 5. The relationship between Fishbone Diagram branches and FMEA risk ratings

Fishbone Branch	Causative factor	RPN	Ranking	Priority Category
Operational	Stock level: warehouse is full or not ready to receive	392	1	Top priority
Method/Environment	Parking too long before departure	378	2	Top priority
Machine	RSK/truck damage or vehicle breakdown	270	3	Monitoring (Highest Severity)
Man	Driver does not shift/update status in APK	210	4	Low priority
Administration	Release or release document is late in publication	125	5	Low priority

The top two factors in the Operations and Methods/Environment branches (Stock Level & Old Parking) contributed a total of 32 of the 41 delay incidents (78%). This phenomenon is in accordance with the Pareto Principle (80/20), where treatment is focused on a small number of critical factors (vital few) to solve the majority of delay problems.

Risk Priority Based Improvement Proposal (5W+1H Matrix)

In order to provide structured and easy-to-implement action recommendations by the management of PT Semen Indonesia Logistik, an Action Plan Matrix was prepared based on the 5W+1H method (What, Why, Where, When, Who, How) in Table 6:

Priorities & Factors	What (Action)	Why (Reason)	Where (Location)	When (time)	Who (PIC)	How (Implementation Method)
Stock Level (RPN 392)	Integration of warehouse stock data with dispatching system	Eliminate waiting time due to full Rembang warehouse.	Operations & Control Tower Department	Before the release of Order Assigned	Control Tower & Logistics Team	Establish a transparent quota system, Reorder Point (ROP), and slotting arrival schedule.
Old Parking (RPN 378)	Parking threshold alarm system.	Detection value is very poor (D=9), long parking is not detected in real-time.	Truck Parking Pool Area	Before the fleet departs	Head of Pool & Operational Excellence	Install a GPS sensor/geofencing APK with a maximum timer of 30 minutes. Automatic notifications are

						sent if the time limit is exceeded.
RSK / Damaged (RPN 270)	Standardization of Pre-trip Inspection (PTI) & Preventive Maintenance.	Has the highest Severity (S=9) which stops operations.	PT SILOG Workshop / Fleet Maintenance	Every day before the unit leaves	Maintenance & Driver Team	Implementation of the PTI digital checklist is mandatory on the APK before the driver can collect the release document.

V. CONCLUSION

Based on the results of research and discussion regarding the analysis of delays in the departure of cement trucks to Rembang at PT Semen Indonesia Logistik, the following conclusions were obtained:

1. Root Cause Mapping: Fishbone Diagram maps five groups of causes of delays, namely Operational (full warehouse stock level), Method/Environment (excessive parking time), Machine (fleet damage/RSK), Human (driver does not shift APK status), and Administration (delay in release documents).
2. FMEA Risk Ranking: The priority order based on RPN is (1) warehouse stock level (392; S = 8, O = 7, D = 7), (2) parking too long (378; S = 7, O = 6, D = 9), (3) fleet/RSK damage (270; S = 9, O = 5, D = 6), (4) driver does not shift APK status (210), and (5) late release documents (125).
3. Focus of Proposed Improvements: Stock levels and excessive parking contributed to 78% (32 of 41) of the delay incidents. Proposed improvements focused on (a) integrating warehouse stock quota data with the fleet assignment system, (b) digital timers and geofencing of parking boundaries based on real-time notifications, and (c) digital Pre-trip Inspection (PTI) to reduce the risk of SSR.

VI. SUGGESTION

Practical Advice for Companies

- Prioritize resource allocation for improvements to stock level constraints and old parking supervision which are the biggest contributors to delays.
- Requires filling in the Root Cause Analysis (RCA) column in the operational application for every fleet experiencing a departure delay of >15 minutes in order to maintain the quality of historical data.
- Evaluate departure punctuality periodically with the target of reducing delays from 15.5% to <10% (referring to the best performance in June 2026 of 10.3%).

Academic Suggestions for Further Research

- Combine FMEA with root cause analysis such as 5-Why or Fault Tree Analysis (FTA) to trace the systemic causes of warehouse stock level discrepancies.
- Expanding the data range and adding expert respondents from various distribution nodes to make the Severity, Occurrence, and Detection assessments more representative.
- Conduct a post-implementation evaluation study (before vs after) to test for reduction in RPN and lateness ratio.

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