

## Mitigation of Fleet Productivity Decline Risk in Land Transportation Through an FMEA Approach at PT XYZ in East Java

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### ABSTRACT

**Objective:** This study aims to describe the risk of declining land-transportation fleet productivity and to identify the contributing factors influencing it at PT XYZ, a logistics company operating in East Java. **Method:** A descriptive qualitative approach was employed using in-depth interviews, direct observation, and documentation analysis, with data triangulated from three key informants. The Failure Mode and Effect Analysis (FMEA) method was applied by scoring each identified failure mode on three parameters severity, occurrence, and detection-which were combined into a Risk Priority Number (RPN). **Results:** Five priority risks were identified: fleet maintenance failure (RPN 405), traffic accidents (RPN 360), overnight unloading delays (RPN 336), driver SOP violations (RPN 160), and overnight loading delays (RPN 72). The contributing factors influencing fleet productivity were grouped into labor, capital, and management dimensions. **Novelty:** Based on these findings, the study proposes a revised Fleet Maintenance Standard Operating Procedure (SOP) as a concrete mitigation output, integrating daily pre-operation checks, mileage-based maintenance notifications, spare-part procurement projections, and periodic performance evaluation, all built on the company's existing digital systems so that implementation requires no major new infrastructure investment.

## INTRODUCTION

Land transportation fleets occupy a strategic position in the distribution and logistics chain of manufacturing and industrial companies, as the smooth movement of goods from production points to end markets depends directly on fleet availability and reliability. A decline in fleet productivity, whether caused by unscheduled vehicle breakdowns, traffic accidents, prolonged waiting time at loading or unloading points, or non-compliance with operational standards, translates almost immediately into delivery delays, rising operational costs, and the erosion of customer trust [1], [2].

Within the cement and building-materials distribution sector, the demand for a reliable and continuously available fleet is particularly high because shipment volumes are large, delivery routes are geographically dispersed, and downtime in one unit can disrupt an entire delivery schedule across multiple regions. Several previous studies have shown that operational risk in road-based logistics fleets tends to be multidimensional, originating from technical failures of the vehicle itself, from the behavior and discipline of drivers, and from external conditions such as infrastructure quality and market demand fluctuation [3], [4].

One systematic approach widely used to map, evaluate, and prioritize operational failure risk is Failure Mode and Effect Analysis (FMEA) [5], [6]. FMEA evaluates every

potential failure mode in a process or system based on three parameters – severity (S), occurrence (O), and detection (D) – which are multiplied to produce a Risk Priority Number (RPN). A higher RPN indicates a failure mode that is more critical and therefore requires a higher priority of mitigation [7], [8]. FMEA has been applied extensively in logistics and transportation contexts, ranging from spare-part inventory risk in warehouses, to cargo discharge operations in ports, to maritime transportation risk management, consistently demonstrating its capacity to translate qualitative risk perceptions into a structured and measurable prioritization scheme [9], [10], [11].

PT XYZ, a logistics subsidiary engaged in cement distribution in East Java, has experienced a persistent fleet productivity problem reflected in a high internal downtime ratio. Internal operational data covering the period of January–June 2025 recorded 876 maintenance cases, 725 overnight unloading delays, 683 overnight loading delays, 114 traffic accidents, and 40 other operational disruptions. These figures indicate that fleet downtime has become a structural issue rather than an incidental one, yet the company has not systematically ranked these failure modes by their actual risk magnitude, nor has it clearly identified the underlying contributing factors behind them.

Based on this background, the study addresses the following research questions: (1) What are the priority risks affecting the decline of land-transportation fleet operational productivity at PT XYZ, as assessed through the FMEA method? and (2) What contributing factors influence the decline of fleet operational productivity at PT XYZ?

This study aims to identify and rank the priority risks affecting fleet productivity decline at PT XYZ using the FMEA method, and to identify the contributing factors underlying that productivity decline. Theoretically, the study contributes to the literature on risk-based fleet management in the land-logistics sector, an area that combines technical, human, and managerial risk dimensions that have rarely been examined together within a single FMEA framework. Practically, the study is expected to provide PT XYZ with a concrete, prioritized basis for designing mitigation actions, particularly through the improvement of its Fleet Maintenance Standard Operating Procedure (SOP).

FMEA was originally developed as a reliability-engineering tool in the aerospace and automotive industries before being adapted widely into supply chain and logistics risk management [12]. In the FMEA procedure, severity reflects the magnitude of consequence should a failure occur, occurrence reflects the frequency with which the failure mode is expected to take place, and detection reflects the ability of existing controls to identify the failure before it causes disruption; each parameter is typically scored on a 1–10 scale and the three scores are multiplied to obtain the RPN [7], [8], [12], [13].

Several recent studies illustrate the breadth of FMEA application in logistics-related risk contexts. A study on inventory operational risk in spare-part warehouses found that the unavailability of critical spare parts produced the highest RPN among the failure modes examined, recommending a more responsive procurement system [9]. Another study combining FMEA with AHP for cargo discharge operations in port terminals showed that integrating multi-criteria weighting with FMEA produced a more nuanced

prioritization than RPN scoring alone [10], [14], [15]. In a similar vein, research on logistics distribution service quality found that inconsistent adherence to standard operating procedures by personnel was a dominant cause of service failure, underscoring the importance of continuous performance monitoring [16].

Beyond the technical dimension, productivity theory suggests that organizational output is jointly determined by labor, capital, and management, with management typically constituting the largest single contributor to annual productivity gains, followed by capital and then labor [17]. This perspective is relevant for interpreting fleet productivity decline, since failure modes identified through FMEA are rarely isolated technical events; they are usually symptomatic of deeper labor-discipline gaps, capital constraints in asset and spare-part provision, or weaknesses in planning and scheduling. The present study draws on both the FMEA framework and this productivity-factor perspective to analyze fleet risk at PT XYZ comprehensively.

## RESEARCH METHOD

This study employed a descriptive qualitative approach, which is appropriate for exploring operational phenomena and risk-management processes in a naturalistic setting where the researcher functions as the primary instrument of data collection [18]. Primary data were obtained through in-depth interviews with three key informants occupying strategic roles in the fleet-operation chain of PT XYZ – namely a Senior Supply Chain Management Manager, a Supply Chain Management Officer, and a General Manager of Supporting Logistics – complemented by direct observation of daily fleet distribution and maintenance activities. Secondary data were drawn from internal company documents, including monthly operational incident reports detailing downtime categories (maintenance, overnight stays, accidents, and SOP-violation cases), supported by relevant scientific literature.

The FMEA method was applied as the primary analytical framework to map potential failure modes by assessing severity, occurrence, and detection, which were then combined into an RPN value following the standard formula:

$$\text{RPN} = \text{Severity (S)} \times \text{Occurrence (O)} \times \text{Detection (D)}$$

To arrive at a single representative score for each failure mode, the S, O, and D values given independently by the three informants were triangulated by averaging and rounding to the nearest whole number, a common practice in qualitative FMEA studies [11], [13]. Internal validity was maintained through purposive sampling of informants directly responsible for fleet operations, control of intervening variables, and consistent use of research instruments across interviews; external validity was supported through triangulation of sources, time, and technique, comparing interview statements with field observation and internal documentation.

The research focus was deliberately bounded to: (1) the identification of failure modes across technical, process, and human-resource dimensions of fleet operation; (2) the analysis of how each failure mode affects fleet productivity metrics such as delivery trip volume, delay frequency, and downtime duration; and (3) the application of FMEA

to determine the most critical risks requiring mitigation. The research locus was PT XYZ, a subsidiary engaged in cement logistics distribution that manages a large land-transportation fleet operating across East Java and neighboring regions, making it a representative case for examining complex and multidimensional fleet-operation risk.

## RESULTS AND DISCUSSION

### Results

PT XYZ is a logistics subsidiary operating in East Java that serves as the backbone of distribution for its parent company's cement products. The company manages a sizeable land-transportation fleet that operates continuously across multiple regions under dynamic road, market, and infrastructure conditions, placing it under constant exposure to operational risk that can directly affect delivery productivity.

The risk management process at PT XYZ begins with failure-mode identification through in-depth interviews, direct observation, and documentation review with three key informants. To obtain a single representative assessment for each failure mode, the severity, occurrence, and detection scores given by the three informants were triangulated by averaging. The occurrence value was treated as a shared parameter derived from historical operational data, since the frequency of each failure mode could be verified directly from company records rather than relying solely on informant perception. Table 1 presents the triangulated S, O, D values and the resulting final RPN for each identified risk.

**Table 1.** Triangulation of S-O-D Scores and Final RPN Calculation

| Identified Risk           | S <sup>1</sup> | S <sup>2</sup> | S <sup>3</sup> | O | D <sup>1</sup> | D <sup>2</sup> | D <sup>3</sup> | Mean<br>S | Mean<br>D | RPN |
|---------------------------|----------------|----------------|----------------|---|----------------|----------------|----------------|-----------|-----------|-----|
| Maintenance Failure       | 8              | 10             | 9              | 9 | 6              | 4              | 4              | 9         | 5         | 405 |
| Overnight Unloading Delay | 7              | 7              | 7              | 8 | 7              | 7              | 4              | 7         | 6         | 336 |
| Overnight Loading Delay   | 2              | 2              | 6              | 8 | 3              | 3              | 4              | 3         | 3         | 72  |
| Traffic Accident          | 7              | 10             | 10             | 5 | 9              | 6              | 8              | 9         | 8         | 360 |
| SOP Violation Case        | 5              | 10             | 10             | 4 | 4              | 5              | 5              | 8         | 5         | 160 |

*Source: Field data, processed 2026.*

The triangulated S, O, and D values were then compiled into a final FMEA table summarizing each risk together with its failure mode, root cause, current control, and resulting RPN-based priority. Table 2 presents this summary, which serves as the

primary reference for formulating the risk-mitigation recommendation discussed in the following section.

**Table 2.** Final FMEA Table for Fleet Operations at PT XYZ

| No. | Identified Risk                              | Failure Mode                                                                       | Main Cause                                                                                                       | Current Control                                                                              | S | O | D | RPN (Priority)   |
|-----|----------------------------------------------|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|---|---|---|------------------|
| 1   | Maintenance (Technical Risk)                 | Sudden component failure (tires, undercarriage, brakes) during delivery operations | Delayed maintenance reporting by drivers; slow-moving spare-part stock; operational negligence                   | Preventive maintenance; standby fleet units                                                  | 9 | 9 | 5 | 405 (Priority 1) |
| 2   | Accident (HR Risk)                           | Traffic accidents during delivery operations                                       | Driver fatigue; unsafe parking; insufficient following distance; vehicle-handling failure                        | Safety equipment checks; driver training; GPS/driving-safety monitoring; safe parking points | 9 | 5 | 8 | 360 (Priority 2) |
| 3   | Overnight Unloading Delay (Operational Risk) | Extended waiting time at unloading points causing trip loss                        | Ineffective schedule coordination; full storage capacity; limited unloading equipment; fluctuating market demand | Customer coordination; dashboard monitoring; order rejection when uncertain                  | 7 | 8 | 6 | 336 (Priority 3) |
| 4   | SOP Violation Case (HR Risk)                 | SOP non-compliance and driver indiscipline                                         | Suboptimal real-time supervision; selective order                                                                | Control-tower monitoring; graduated sanctions;                                               | 8 | 4 | 5 | 160 (Priority 4) |

| No. | Identified Risk                            | Failure Mode                                                     | Main Cause                                                                          | Current Control                                                                       | S | O | D | RPN (Priority)  |
|-----|--------------------------------------------|------------------------------------------------------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---|---|---|-----------------|
|     |                                            |                                                                  | acceptance by drivers; spare-part theft/swap                                        | driver education                                                                      |   |   |   |                 |
| 5   | Overnight Loading Delay (Operational Risk) | Delayed loading process due to queues and limited plant capacity | Limited plant storage; manual loading process; orders not yet released by marketing | Operations-marketing coordination; redirection to alternate plants; scheduling system | 3 | 8 | 3 | 72 (Priority 5) |

Source: Field data, processed 2026.

### Discussion

The analysis produced a clear risk-treatment hierarchy from highest to lowest RPN: (1) maintenance failure (RPN 405), (2) traffic accident (RPN 360), (3) overnight unloading delay (RPN 336), (4) SOP violation (RPN 160), and (5) overnight loading delay (RPN 72).

The maintenance-failure risk obtained the highest RPN, driven by a severity score of 9, an occurrence score of 9, and a detection score of 5. The high severity reflects the significant trip losses and high cost burden caused by sudden component failure, while the high occurrence is consistent with historical records showing maintenance cases reaching as high as 173 units in a single month, placing it in the highest frequency category. A moderate detection score indicates that although early-warning features and pre-operation inspection already exist, impending failures are still sometimes missed until they cause disruption. This combination positions maintenance failure as the most urgent risk requiring mitigation.

The accident risk ranked second with an RPN of 360, characterized by high severity (9) and a notably high detection score (8), the highest among all five risks. This indicates that accidents are inherently the most difficult failure mode to detect in advance, since they occur abruptly and are influenced by numerous uncontrolled variables. Although their occurrence frequency is comparatively lower, the severity in terms of driver safety and vehicle damage is substantial enough to place this risk just below maintenance failure.

The overnight unloading delay risk, with an RPN of 336, was driven primarily by a high occurrence score (8), consistent with historical data showing unloading delays reaching 176 units in a single month. Although the per-incident severity is lower than

that of an accident, the cumulative revenue loss associated with repeated overnight delays makes this risk a priority business concern.

SOP violation cases produced an RPN of 160, combining a relatively low occurrence (4) with a comparatively high severity (8), reflecting that although violations occur infrequently, each incident can carry meaningful financial and reputational consequences. The lowest-ranked risk, overnight loading delay (RPN 72), exhibited a relatively high occurrence (8) but the lowest severity (3) among all risks, indicating that while loading queues happen frequently, their impact per incident is comparatively mild and more readily anticipated through early plant coordination.

Mapped onto the underlying risk categories, maintenance failure represents the technical-risk dimension and occupies the highest priority; accident and SOP-violation risks represent the human-resource (HR) dimension, ranked second and fourth respectively; while overnight unloading and loading delays represent the operational-risk dimension, ranked third and fifth. This distribution indicates that technical and HR-related risks currently carry greater urgency than purely process-related operational risks within PT XYZ's fleet operations.

Triangulated interview data and supporting operational records identified three interrelated contributing factors behind the decline in fleet productivity, consistent with the labor-capital-management productivity framework [17]. The labor factor is reflected in driver indiscipline toward standard operating procedures, the most frequently cited root cause across all five risk categories, manifesting as delayed maintenance reporting, fatigue-related accidents, selective order acceptance, and unauthorized spare-part handling; although a driver-safety monitoring system has been implemented, its effectiveness in the field remains limited, consistent with prior research indicating that inconsistent adherence to standard procedures by personnel is a leading cause of distribution-service failure [16].

The capital factor concerns constraints in the timely provision of slow-moving spare parts and a limited number of standby fleet units, which directly extend downtime duration since the available standby units cannot fully cover the company's wide operating area; temporary measures such as borrowing spare parts between units only mitigate the symptom rather than resolving the underlying shortage. This pattern echoes earlier findings that spare-part unavailability tends to generate the highest RPN among warehouse-related logistics risks, underscoring the need for a more responsive procurement and stock-planning system [9].

The management factor relates to fleet planning and scheduling that remain only partially effective due to dependence on fluctuating market demand, resulting in a management style that is predominantly corrective rather than preventive; daily coordination meetings and a transportation management system already exist, but the absence of dedicated, fixed driver-route assignments continues to make planning reactive, consistent with the view that weak proactive responsiveness in operational management tends to make internal operational risk more difficult to control over time [4]. These three factors interact and reinforce one another in shaping the overall pattern

of fleet productivity decline, suggesting that a shift from a reactive toward a proactive, data-driven risk-management approach is the most pressing strategic step for PT XYZ to sustain its fleet productivity targets.

Because maintenance failure carries the highest RPN and is rooted in delayed maintenance reporting, slow spare-part procurement, and weak periodic detection, this study's primary practical contribution is a revised Fleet Maintenance Standard Operating Procedure (SOP) for PT XYZ. The proposed SOP closes the gaps identified through the FMEA analysis by formalizing four stages: (1) daily pre-operation checks of seven critical components (tires, brakes, battery, transmission, oil, lights, and undercarriage) through a digital safety-equipment-check form; (2) a structured repair workflow in which a work order is issued, validated, diagnosed, repaired, and quality-checked before the vehicle is returned to service; (3) mileage-based notification for periodic preventive maintenance; and (4) monthly evaluation and reporting of maintenance costs and performance as the basis for continuous improvement.

Importantly, the proposed SOP requires no major new infrastructure investment, as it builds on systems the company already operates—its transportation management system, fleet-integrated operation application, and driver-safety monitoring module—by strengthening, standardizing, and formalizing practices that are already partially in place but not yet consistently enforced. Consistent implementation of this SOP is expected to reduce the fleet downtime ratio and, in turn, contribute directly to improved fleet productivity and utilization at PT XYZ.

## CONCLUSION

**Fundamental Finding:** This study identifies five priority risks affecting land-transportation fleet productivity at PT XYZ based on RPN ranking—maintenance failure (RPN 405), traffic accidents (RPN 360), overnight unloading delays (RPN 336), SOP violations (RPN 160), and overnight loading delays (RPN 72)—alongside three interacting contributing factors: labor (driver indiscipline), capital (spare-part and standby-fleet constraints), and management (predominantly corrective rather than preventive planning). **Implication:** The findings indicate that technical and human-resource risks currently require more urgent mitigation than process-related operational risks, and that the existing Fleet Maintenance SOP needs to be strengthened with daily pre-operation checks, mileage-based maintenance triggers, and structured monthly evaluation to close the detection gap identified in the maintenance-failure risk. **Limitation:** This study was conducted within a descriptive qualitative design at a single research locus and relies on triangulated informant judgment for severity and detection scoring, which, while methodologically appropriate for exploratory FMEA, may benefit from further validation through quantitative or longitudinal data in future research. **Future Research:** Subsequent studies may extend this analysis by combining FMEA with multi-criteria methods such as AHP or fuzzy logic to refine risk weighting, by tracking downtime-ratio trends after SOP implementation to evaluate mitigation effectiveness,

and by replicating the framework across other fleet-based logistics companies to test the generalizability of the identified risk and productivity factors.

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