Integration of Human Factors Analysis and Classification System (HFACS) and Failure Mode And Effects Analysis (FMEA) In Fleet Traffic Accident Risk Analysis At PT Semen Indonesia Logistik

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Abstract.
Traffic accidents involving distribution fleets are a safety concern that can be influenced by human factors, environmental conditions, supervision, and organizational factors. This study aims to identify the factors contributing to traffic accidents and determine risk priorities as a basis for developing recommendations to improve fleet safety at PT Semen Indonesia Logistik. The methods used are the Human Factors Analysis and Classification System (HFACS) and Failure Mode and Effects Analysis (FMEA). HFACS is used to classify factors contributing to accidents, while FMEA is used to prioritize risks based on the Risk Priority Number (RPN). The integration of these methods enables the study not only to identify accident causation factors but also to determine which risks require the most immediate attention. The HFACS analysis shows that Adverse Mental States is the most dominant category, with 35 occurrences (18.92%), followed by Decision Errors with 33 occurrences (17.84%) and Perceptual Errors with 28 occurrences (15.14%). Meanwhile, the FMEA results indicate that driver fatigue has the highest RPN of 504, followed by failure to maintain a safe following distance with an RPN of 378 and failure to detect objects in blind spots with an RPN of 324. Based on these findings, the recommended improvements include implementing fatigue management, regulating working hours and rest periods, providing defensive driving training, increasing blind-spot awareness, and optimizing driving behavior monitoring. The integration of HFACS and FMEA can support the systematic identification of accident causation factors and the prioritization of risk control measures.
Keywords: *traffic accidents, HFACS, FMEA, RPN and fleet safety.*

I. INTRODUCTION

Occupational Safety and Health (K3) is an important aspect in company operational activities because it is related to worker protection, accident risk control, and the creation of a safe and productive work environment.[1]In logistics companies, distribution activities using transportation fleets carry a relatively high level of risk because they involve interactions between people, vehicles, the environment, and the company's management system. Traffic accidents in distribution activities can have various consequences, such as worker injuries, asset damage, distribution delays, and financial losses for the company.[2].

PT Semen Indonesia Logistik (SILOG) is a company engaged in logistics services and material distribution with operational activities dominated by the use of land transportation fleets. The high mobility of the fleet causes the company to face various potential risks of traffic accidents, especially those related to drivers and travel activities. Based on data from the Land SHE Unit of PT Semen Indonesia Logistik in 2025, 224 cases of traffic accidents were recorded with an Accident Rate (AR) of 0.97. Of the total incidents, there were 31 cases of minor accidents, 174 cases of moderate accidents, and 19 cases of serious accidents. In the same period, the company had 13,673 active fleets with a total distance traveled of 23,138,175 km. The accidents also caused the company a loss of Rp9,000,000,000, as well as claims and fines of Rp10,400,000.

Table 1. Traffic accident data

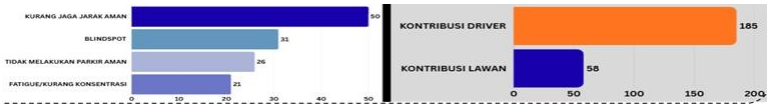
STATISTIK KECELAKAAN LALU LINTAS 2025
SEMEN INDONESIA LOGISTIK GROUP
2025

NO	BULAN	JUMLAH ARMADA AKTIF	JUMLAH KILOMETER	JUMLAH KECELAKAAN				AR KECELAKAAN	SI KECELAKAAN
				RINGAN	SEDANG	BERAT	MD		
1	Januari	1.219	1.920.987	5	12	1	0	0,94	0
2	Februari	1.169	1.911.397	4	14	2	0	1,05	0
3	Maret	1.038	1.800.981	0	13	1	0	0,78	0
4	April	1.107	1.897.523	0	13	2	0	0,79	0
5	Mei	1.085	1.849.821	1	18	1	0	1,08	0
6	Juni	1.102	1.912.821	4	12	2	0	0,94	0
7	Juli	1.147	1.988.620	4	17	1	0	1,11	0
8	Agustus	1.129	1.967.628	0	18	1	0	0,97	0
9	September	1.169	1.979.026	2	16	0	0	0,91	0
10	October	1.143	1.959.034	3	9	3	0	0,77	0
11	November	1.179	1.962.907	4	16	1	0	1,07	0
12	December	1.186	1.987.430	4	16	4	0	1,21	0
	TOTAL	13.673	23.138.175	31	174	19	0	0,97	0

Source: PT Semen Indonesia Logistik, SHE Division, 2025.

The data shows that traffic accidents remain a safety issue that requires attention. Based on the causal factors, the largest contributor was drivers (185 cases), while opposing vehicles accounted for 58 cases. This indicates that the human factor plays a significant role in traffic accidents within the company's operational environment.

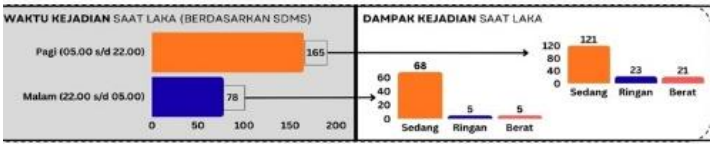
Table 2. Factors causing accidents



Source: PT Semen Indonesia Logistik, SHE Division, 2025.

In addition to causal factors, the characteristics of the time and location of the incident are also important information in understanding accident patterns. Based on the time of incident, the most accidents occurred between 5:00 AM and 10:00 PM, with 165 cases.

Table 3. The most common time for accidents to occur



Source: PT Semen Indonesia Logistik, SHE Division, 2025.

Based on location, the province with the highest number of accidents was East Java with 88 cases, followed by Central Java with 77 cases and West Java with 45 cases. At the district/city level, the highest number of accidents occurred in Tuban with 31 cases, Rembang with 21 cases, and Bekasi with 11 cases.

Table 4. Location of the incident



Source: PT Semen Indonesia Logistik, SHE Division, 2025.

The large number of incidents and the dominant role played by drivers demonstrate the need for analysis that goes beyond the immediate causes of accidents. Some commonly used accident cause analysis methods include Fishbone Diagrams, Fault Tree Analysis (FTA), and Root Cause Analysis (RCA).[3]Fishbone diagrams can be used to identify cause-and-effect relationships based on several groups of factors, while FTA is used to trace the logical relationships between the causes of an event. Meanwhile, RCA focuses on identifying root causes to determine appropriate corrective actions.[4]. While these methods can help identify the causes of accidents, accident analysis in transportation activities also needs to consider the interaction between human factors, environmental conditions, supervision, and organizational influences.[5].

One approach that can be used to analyze the relationship between human and organizational factors is the Human Factors Analysis and Classification System (HFACS).[6]. HFACS was developed based on the Swiss Cheese Model introduced by Reason and classifies accident-causing factors into four levels, namely Unsafe Acts, Preconditions for Unsafe Acts, Unsafe Supervision, and Organizational Influences.[7]This approach allows accident causes to be analyzed more systematically, from unsafe acts at the individual level to supervisory and organizational conditions.

The application of HFACS in various sectors shows that accidents are not only related to driver or worker errors, but can also be influenced by weaknesses in supervision and organizational processes.[5], for example, showed that organizational factors, supervision, and driver behavior contributed to human error in mixer truck transportation safety.[8]shows that inadequate supervision and decision errors are factors that contribute to fatal mining accidents, whereas[9]This finding indicates the contribution of organizational processes to workplace accidents. These findings demonstrate that the HFACS approach can provide a more comprehensive picture of the causal factors of accidents.

However, HFACS primarily serves to identify and classify causal factors, so it does not directly prioritize the risk level of each failure mode found. To complement this stage, Failure Mode and Effects Analysis (FMEA) can be used as a risk analysis method that identifies failure modes, their causes, and impacts, then determines priorities based on the levels of Severity (S), Occurrence (O), and Detection (D). The values of these three parameters are traditionally used to determine the Risk Priority Number (RPN) as the basis for risk ranking.[10]. FMEA has also been applied in various safety and transportation contexts to help determine the priority of control actions based on the level of risk.[11].

The integration of HFACS and FMEA was carried out sequentially, namely the HFACS classification results were used as the basis for identifying failure modes which were then analyzed using FMEA. HFACS factors, such as

Adverse Mental States, Decision Errors, and Perceptual Errors, were mapped to relevant failure modes, such as driver fatigue, failure to maintain a safe distance, and failure to detect objects in the blind spot area. Next, FMEA was used to determine risk priorities based on RPN values. Both methods were chosen because HFACS is able to classify accident-causing factors at various levels, while FMEA assesses and prioritizes risks quantitatively. This integration is expected to support the preparation of more targeted safety improvement actions for PT Semen Indonesia Logistik's fleet.

Based on these conditions, this study uses the HFACS and FMEA approaches to analyze traffic accidents in the PT Semen Indonesia Logistik fleet. HFACS is used to identify and classify the causal factors of accidents based on unsafe acts, supporting conditions, supervision, and organization. Furthermore, FMEA is used to identify failure modes related to these causal factors and determine risk priorities based on the levels of Severity, Occurrence, and Detection.[24]The results of the analysis are expected to provide a more focused basis for determining priority corrective actions so that the company can improve the effectiveness of risk control and minimize traffic accidents in fleet operations.

Research methods

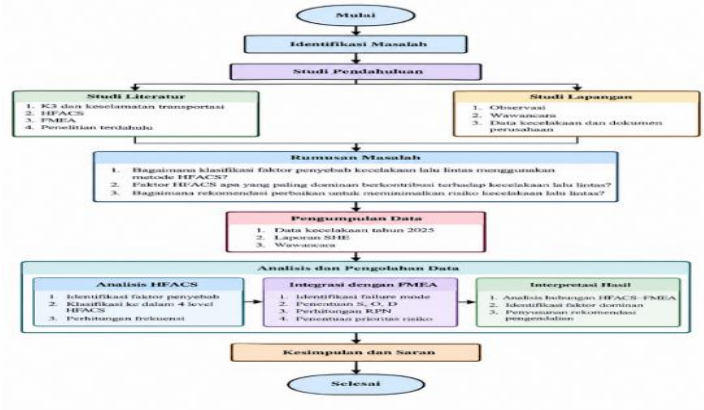


Fig. 1. Research Flow

This study uses a descriptive approach by combining the Human Factors Analysis and Classification System (HFACS) and Failure Mode and Effects Analysis (FMEA) methods. HFACS is used to identify and classify factors contributing to accidents based on the level of human action, supporting conditions, supervision, and organization.[12]This layered approach helps accident analysis not only focus on individual errors, but also consider the underlying system factors.[13]

Next, FMEA is used to evaluate potential failures, identify their causes and impacts, and determine risk priorities using Severity (S), Occurrence (O), and Detection (D) values.[14],[15]. The combination of the two methods is carried out so that the causal factors that have been classified through HFACS can be analyzed further and sorted based on treatment priority.[16].

The research data comes from traffic accident data from PT Semen Indonesia Logistik's fleet during 2025, supplemented by observations, interviews, accident reports, and available investigations. Data processing was carried out through three main stages: the application of HFACS, the application of FMEA, and the integration of the results of both methods to develop safety improvement recommendations.

II. HFACS METHOD

HFACS is a classification framework for accident causation factors that identifies human and organizational contributions at various levels. This method was developed by Shappell and Wiegmann to facilitate systematic accident investigations.[1]. Its application to various transportation contexts also shows that the analysis needs to consider operator actions, supporting conditions, supervision, and organizational influences.[17].

The application of HFACS in this study uses secondary data in the form of 224 traffic accidents involving PT Semen Indonesia Logistik's fleet during 2025. Therefore, the unit of analysis in this study is the accident case, not the respondents. Supporting data is obtained through accident reports, investigation results, field observations, as well as interviews and expert judgment from Safety, Health, and Environment (SHE) personnel at PT Semen Indonesia Logistik. However, the source documents used do not specifically list the number and identities of interview informants.

The stages of implementing HFACS in this study are as follows.

1. Accident data collection. Collecting accident data of PT Semen Indonesia Logistik fleet during 2025. Supporting data is obtained through accident reports, investigation results, field observations, as well as interviews and expert judgment from SHE personnel who are related to operational safety and accident handling.
2. Identifying causal factors of the accident. Reviewing the chronology and causal information of the accident to identify factors related to the driver, operational environment, supervision, and organization.
3. Classification of causal factors. Grouping identified factors into four HFACS levels: Unsafe Acts, Preconditions for Unsafe Acts, Unsafe Supervision, and Organizational Influences. This classification follows the HFACS principles used to trace active and latent factors in accidents.[1].
4. Factor frequency recapitulation. Calculate the frequency of each category based on the data coding results. The percentage of each category is calculated using the following equation.

$$P_i = \frac{f_i}{N} \times 100\%$$

Information:

- P_i= percentage of category – $.i$
- f_i= frequency of factor in category – $.i$
- N= total occurrence of factors classified.

5. Dominant factor analysis. Compare the frequency and percentage of each category to determine the most frequently identified factors. The results of this analysis are then used as the basis for mapping failure modes in the FMEA.

FMEA method

FMEA is a risk analysis method used to identify potential failures, their causes, impacts, and priority corrective actions. In a conventional FMEA, risk priority is calculated using Severity, Occurrence, and Detection values, which are multiplied to obtain a Risk Priority Number (RPN).[18]However, RPN has limitations because different combinations of scores can produce the same value, so the ranking results need to be interpreted together with information on causes and impacts.[19].

The application of FMEA in this study is based on the ten factors resulting from the HFACS classification that have been mapped in Table 2. These factors are used to determine the failure mode, identify the causes and impacts of failure, and determine risk priorities. The assessment is carried out on three parameters, namely Severity (S), Occurrence (O), and Detection (D), with a scale of 1–10 according to the assessment criteria used in the study.

The assessment of these three parameters must be based on relevant information and the considerations of parties who understand operational safety and traffic accident risks. Parties who can be involved as assessors include Safety, Health, and Environment (SHE) personnel, officers handling accident investigations, or related personnel with experience in road safety oversight. However, the number and identities of assessors must be tailored to the actual research implementation and cannot be determined solely based on the FMEA method.

The stages of implementing FMEA in this research are as follows[25].

1. Determining failure modes. Using the ten factors resulting from the HFACS classification mapped in Table 2 as a basis for determining the potential failure modes to be analyzed.
2. Identify the cause of failure. Describe the cause of each failure mode, such as fatigue, lack of rest, poor driving decisions, limited visibility, or suboptimal supervision.
3. Identify the failure effect. Explain the potential impact of each failure mode, such as decreased concentration, collision with the vehicle in front, collision due to blind spots, or repeated unsafe driving behavior.
4. Risk assessment. Assign S, O, and D scores on a scale of 1–10 according to the assessment design used in the study. Scoring should be based on clear assessment criteria, not simply on the order of factor frequency.
5. RPN Calculation. Calculate the RPN value for each failure mode using the following equation.

$$RPN = S \times O \times D$$

Information:

- (S) (Severity) = severity of the impact of the failure.
- (O) (Occurrence) = the level of possibility or frequency of failure occurring.
- (D) (Detection) = the level of difficulty in detecting failure before it causes an impact.

6. Risk ranking. Order RPN values from highest to lowest to determine treatment priority. If multiple RPN values are identical, the order must be explained using additional criteria or presented as equal priority.
7. Developing improvement recommendations. Formulating control actions based on the causes, impacts, and priority levels of each failure mode. The literature on driver fatigue indicates that drowsiness is associated with the risk of traffic accidents, so fatigue control is relevant to consider in the context of this study.[20].

Integration of HFACS and FMEA Methods

The integration of HFACS and FMEA is performed by using the HFACS classification results as a basis for determining failure modes, which are further analyzed using FMEA. HFACS helps explain the structure of causal factors at the human and organizational levels.[21], while FMEA is used to assess and rank potential risks.[22]. The systemic accident analysis approach also emphasizes the importance of linking operational errors with supervisory and organizational factors to formulate more comprehensive preventive measures.[23].

The stages of integration of the two methods in this research are as follows.

1. Taking the HFACS classification results. Using the ten factor categories presented in Table 1 as the basis for further analysis.
2. Map HFACS factors to FMEA. Link each category to the failure mode, root cause, and potential impact as listed in Table 2.
3. Linking classification results to risk assessment. Combining HFACS frequency information with RPN values obtained through FMEA to distinguish between frequently occurring factors and those with high risk priority.
4. Determine repair priorities. Use RPN values as the basis for ranking, while still considering the cause and impact categories of failure.
5. Develop improvement recommendations. Develop control measures based on FMEA priorities, including fatigue control, improved driving behavior, blind spot risk control, enhanced monitoring, and follow-up on recurrent unsafe behavior.

III. RESULTS AND DISCUSSION

This study analyzes traffic accident data from PT Semen Indonesia Logistik's fleet during 2025 to identify contributing factors and determine risk priorities. The analysis was conducted using the Human Factors Analysis and Classification System (HFACS) method to classify accident-causing factors based on human and organizational factors. Furthermore, the results of the identified causal factors were analyzed using Failure Mode and Effects Analysis (FMEA) to determine risk priorities based on Severity, Occurrence, and Detection values.

Observation and Interview

Field observations and interviews with parties involved in transportation operations indicate that traffic accidents involving PT Semen Indonesia Logistik's fleet are influenced by various factors, including driver-related factors, environmental conditions, and monitoring systems. Accident data from 2025 showed 224 traffic accidents, with 185 cases attributed to driver factors. This situation demonstrates that the human factor is a crucial aspect in accident control efforts.

Identification and Analysis of Accident Causative Factors

Identification of causal factors was conducted by reviewing accident reports, investigation results, observations, and interview results. From this process, several causal factors were obtained, namely not maintaining a safe distance, vehicle blind spots, not practicing safe parking, fatigue or lack of concentration, lack of understanding of route characteristics, heavy traffic conditions, suboptimal monitoring of driving behavior, findings of repeated unsafe driving, suboptimal use of safety technology, and evaluation of safety programs that still need to be improved. These factors were then classified using the HFACS method. HFACS groups accident causal factors into four levels, namely Unsafe Acts, Preconditions for Unsafe Acts, Unsafe Supervision, and Organizational Influences. This approach is used to determine the relationship between unsafe acts and conditions that support their occurrence, the supervisory system, and organizational factors.

Classification of Causal Factors Using HFACS

The classification results using the Human Factors Analysis and Classification System (HFACS) show that 185 occurrences of accident-causing factors can be grouped into four levels: Unsafe Acts, Preconditions for Unsafe

Acts, Unsafe Supervision, and Organizational Influences. The distribution of factors in each category is shown in Table 1.

Table 1. Frequency of Accident Causal Factors Based on HFACS

HFACS Level	Category	Frequency	Percentage (%)
Unsafe Acts	*Decision Errors*	33	17.84
	Perceptual Errors	28	15.14
	Routine Violations	10	5.41
Preconditions for Unsafe Acts	*Physical Environment*	23	12.43
	Adverse Mental States	35	18.92
	Personal Readiness	18	9.73
Unsafe Supervision	*Inadequate Supervision*	15	8.11
	Failure to Correct Known Problems	12	6.49
Organizational Influences	*Resource Management*	4	2.16
	Organizational Process	7	3.78
Total		185	100

The percentage of each category was obtained by comparing the frequency of the category to the total identified causal factors. The results showed that Adverse Mental States had the highest frequency, namely 35 incidents or 18.92%, followed by Decision Errors with 33 incidents or 17.84%, and Perceptual Errors with 28 incidents or 15.14%. These results indicate that the causal factors of accidents are not only dominated by unsafe acts, but also by the conditions that precede the occurrence of these actions. In fact, the Preconditions for Unsafe Acts category shows a significant contribution because it includes Adverse Mental States, Physical Environment, and Personal Readiness. This condition shows that the condition of the driver and the operational environment need to be given attention in accident prevention efforts.

Integration of HFACS and FMEA

HFACS results provide information on factors contributing to accidents based on human and organizational levels. However, HFACS does not directly provide a risk ranking for each failure mode. Therefore, FMEA is used as a follow-up step to identify failure modes, analyze their causes and impacts, and determine the priority of corrective actions. Based on the HFACS identification results, several factors can be translated into failure modes for analysis using FMEA. This integration is shown in Table 2.

Table 2. Integration of HFACS Factors with Failure Mode FMEA

No.	HFACS Factors	Failure Mode	The main cause	Potential Impact
1	*Adverse Mental States*	The driver is experiencing fatigue	Fatigue, lack of rest, long journey	Decreased concentration and alertness
2	*Decision Errors*	Not keeping a safe distance	Improper driving decision making	Collision with the vehicle in front
3	*Perceptual Errors*	Does not detect objects in blind spots	Limited vehicle visibility	Collision with other vehicles/objects
4	*Routine Violations*	Parking not according to procedure	Non-compliance with safe parking procedures	Risk of collision while parking
5	*Personal Readiness*	Lack of understanding of route characteristics	Route knowledge is inadequate	Mistakes in anticipating road conditions
6	*Physical Environment*	Driving in heavy traffic conditions	Traffic density and complexity	Increased potential for traffic conflicts
7	*Inadequate Supervision*	Monitoring of driving behavior is not optimal	Supervision is not consistent	Risky behavior is not immediately corrected
8	*Failure to Correct Known Problems*	*Unsafe driving*repetitive	Corrective follow-up has not been effective	Repeat violations and increased risk
9	*Resource Management*	Safety technology is not yet optimal	Utilization of GPS/telematics is not yet optimal	Driving risks are difficult to monitor
10	*Organizational Process*	Safety program evaluation is not optimal	Monitoring and evaluation are not yet sustainable	The effectiveness of the safety program is not yet optimal

The table shows that HFACS results can be used as a basis for determining failure modes in FMEA. For example, Adverse Mental States, which is the dominant factor, translates into a failure mode of driver fatigue. Similarly, Decision Errors translate into failures such as not maintaining a safe distance, while

Perceptual Errors relate to failure to detect objects in blind spots. With this approach, HFACS serves to explain the structure and causes of accidents, while FMEA is used to determine risk priorities and control measures. The integration of these two methods provides a more systematic analysis because the human and organizational factors identified do not stop at the classification stage but can be continued with risk assessment.

FMEA Analysis

Based on the HFACS classification results, there are ten factors that can be developed into failure modes for analysis using the Failure Mode and Effects Analysis (FMEA) method. FMEA analysis is performed to determine the risk priority level based on three parameters: Severity (S), Occurrence (O), and Detection (D). The values of these three parameters are then used to calculate the Risk Priority Number (RPN) using the equation:

$$RPN = S \times O \times D$$

In this research simulation, the S, O, and D assessment scales range from 1 to 10. The Severity value indicates the severity of the impact, Occurrence indicates the likelihood of a failure mode occurring, while Detection indicates the system's ability to detect failures before they cause an impact.

Table 3.FMEA Analysis Results

No.	Failure Mode	HFACS	S	O	D	RPN	Priority
1	The driver experienced fatigue	*Adverse Mental States*	9	8	7	504	1
2	Not keeping a safe distance	*Decision Errors*	9	7	6	378	2
3	Does not detect objects in blind spots	*Perceptual Errors*	9	6	6	324	3
4	Monitoring of driving behavior is not optimal	*Inadequate Supervision*	8	6	6	288	4
5	*Unsafe driving*repetitive	*Failure to Correct Known Problems*	8	6	6	288	5
6	Not parking according to procedure	*Routine Violations*	7	5	6	210	6
7	Lack of understanding of route characteristics	*Personal Readiness*	7	5	5	175	7
8	Driving in heavy traffic conditions	*Physical Environment*	8	5	4	160	8
9	The use of safety technology is not optimal	*Resource Management*	7	4	5	140	9
10	Safety program evaluation is not optimal	*Organizational Process*	7	4	5	140	10

Discussion of FMEA Results

Based on Table 3, the failure mode with the highest RPN value is driver fatigue, with an RPN of 504. This factor is in the Adverse Mental States category in the HFACS and was previously the factor with the highest frequency, with 35 occurrences or 18.92%. These results demonstrate consistency between the HFACS frequency analysis and FMEA risk priorities. Fatigue has a high level of severity because it can reduce concentration, alertness, perceptual abilities, and decision-making abilities while driving.

The second priority was not maintaining a safe distance, with an RPN of 378. This factor falls under the Decision Errors category and had a frequency of 33 occurrences. Not maintaining a safe distance can increase the likelihood of a collision, especially when the vehicle in front brakes suddenly. The high RPN value indicates that controlling safe distance behavior needs to be a primary focus of any driving safety program.

The third priority is the failure to detect objects in the blind spot area with an RPN value of 324. This factor falls into the Perceptual Errors category and has a frequency of 28 occurrences. The presence of areas that cannot be directly observed by the driver increases the risk of collision with other vehicles or objects. Control can be achieved by increasing the driver's understanding of the characteristics of blind spots, using cameras or supporting sensors, and checking the condition of the mirrors before driving.

Furthermore, suboptimal monitoring of driving behavior resulted in an RPN of 288, categorizing it as "Inadequate Supervision." These results indicate that supervision remains crucial, albeit at a lower frequency than direct human intervention. A suboptimal monitoring system can lead to risky driving behavior not being promptly identified and corrected.

The same RPN value, 288, was obtained for repeated unsafe driving failure modes in the Failure to Correct Known Problems category. This condition indicates that findings of unsafe behavior require

effective corrective action. If corrective action is only implemented administratively without further monitoring, the same behavior has the potential to recur.

Failure to park according to procedure receives an RPN of 210 and is ranked sixth in priority. Although the RPN is lower than some of the previous factors, violating parking procedures still requires control because it can lead to collisions when vehicles stop, maneuver, or exit the parking area.

The factor of not understanding route characteristics received an RPN score of 175. This factor is included in Personal Readiness. Understanding route characteristics is necessary for drivers to anticipate road conditions, traffic density, vulnerable points, and changes in environmental conditions during the trip.

Meanwhile, heavy traffic conditions received an RPN score of 160. This condition falls under the Physical Environment category. While environmental factors cannot always be directly controlled by companies, their risks can be mitigated through trip planning, timing, identifying risky routes, and implementing a Journey Management Plan.

The factors of suboptimal utilization of safety technology and suboptimal evaluation of safety programs each received an RPN score of 140. Both factors have a lower priority based on the FMEA simulation, but remain important because they relate to the organization's ability to maintain the effectiveness of safety systems. Optimizing GPS or telematics, dashcams, and driving behavior monitoring systems can help improve a company's ability to detect and respond to risky behavior.

Integration of HFACS and FMEA Results

The analysis results show that HFACS and FMEA provide complementary information. HFACS is used to determine the structure and sources of accident causative factors, while FMEA is used to determine the risk priority of each failure mode. When the results of the two methods are compared, a clear relationship is found. Adverse Mental States is the factor with the highest frequency in HFACS, and failure modes related to fatigue also produce the highest RPN in FMEA. This indicates that driver fatigue is not only frequently found as a causal factor, but also has a high potential impact and risk level.

Table 4. Integration of HFACS and FMEA

Priority	HFACS Factors	HFACS Frequency	Failure Mode	RPN
1	*Adverse Mental States*	35 (18.92%)	The driver is experiencing fatigue	**504**
2	*Decision Errors*	33 (17.84%)	Not keeping a safe distance	**378**
3	*Perceptual Errors*	28 (15.14%)	Does not detect objects in blind spots	**324**
4	*Inadequate Supervision*	15 (8.11%)	Monitoring of driving behavior is not optimal	**288**
5	*Failure to Correct Known Problems*	12 (6.49%)	*Unsafe driving*repetitive	**288**
6	*Routine Violations*	10 (5.41%)	Parking not according to procedure	**210**
7	*Personal Readiness*	18 (9.73%)	Lack of understanding of route characteristics	**175**
8	*Physical Environment*	23 (12.43%)	Heavy traffic conditions	**160**
9	*Resource Management*	4 (2.16%)	Safety technology is not yet optimal	**140**
10	*Organizational Process*	7 (3.78%)	Safety program evaluation is not optimal	**140**

Improvement Recommendations Based on FMEA Priorities

Based on the FMEA simulation results, corrective actions can be focused on the five failure modes with the highest RPN.

Table 5. Recommendations for Improvement

Priority	Failure Mode	RPN	Improvement Recommendations Based on the Hierarchy of Control
1	The driver is experiencing fatigue	504	Elimination: Stopping the journey when the driver is drowsy. Administrative: Setting working hours, rest periods, and fit-to-work checks. Engineering: Drowsiness detection system.
2	Not keeping a safe distance	378	Engineering: Collision warning systems and telematics. Administrative: Implementation of safe distance SOPs and defensive driving training.
3	Does not detect blind spots	324	Engineering: Installation of cameras and blind spot sensors. Administrative: Blind spot awareness training and pre-maneuver area inspections.
4	Behavior monitoring is not optimal	288	Engineering: Optimizing GPS, dashcam, and SDMS. Administrative: Evaluating driving behavior and following up on monitoring results

			periodically.
5	Repeated unsafe driving	288	Elimination: Temporary suspension of driving duties if the behavior is dangerous. Administrative: Coaching, retraining, competency evaluation, and sanctions as per regulations.

Based on the results of the FMEA analysis and control recommendations according to the K3 control hierarchy, the main priority for improvement is controlling driver fatigue because it has the highest RPN value, namely 504. Control is carried out by stopping the trip when the driver is sleepy, setting work hours and rest times, checking fit to work, and utilizing a drowsiness detection system if available.

The next priority is controlling the risks of not maintaining a safe distance (RPN 378) and not detecting blind spots (RPN 324). Improvements can be made through the implementation of collision warning systems, the installation of cameras or blind spot sensors, and the implementation of safe distance standard operating procedures (SOPs) and defensive driving training.

In terms of supervision, the risk of suboptimal driving behavior monitoring (RPN 288) can be controlled through optimization of GPS, dashcams, and the Safety Driving Monitoring System (SDMS), accompanied by regular evaluation and follow-up of monitoring results. Meanwhile, repeated unsafe driving (RPN 288) requires coaching, retraining, competency evaluation, and temporary suspension of driving duties if the driver's behavior is dangerous.

Thus, improvement recommendations focus not only on driver behavior but also include controlling working conditions, implementing safety technologies, and improving monitoring systems. The selection of actions is tailored to the characteristics of each risk and prioritizes relevant controls based on the Occupational Health and Safety (OHS) hierarchy of controls. This approach is also in line with the HFACS, which considers the contributions of human factors, operational conditions, supervision, and organization to accident occurrence.

IV. CONCLUSION

Based on the research results, traffic accidents involving PT Semen Indonesia Logistik's fleet are influenced by various factors including human aspects, environmental conditions, supervision, and organization. The analysis results using the Human Factors Analysis and Classification System (HFACS) method show that the Adverse Mental States category is the most dominant factor, with 35 occurrences or 18.92%, followed by Decision Errors with 33 occurrences or 17.84%, and Perceptual Errors with 28 occurrences or 15.14%. The results of the Failure Mode and Effects Analysis (FMEA) analysis show that driver fatigue is the highest risk priority with a Risk Priority Number (RPN) value of 504, followed by failure to maintain a safe distance of 378 and failure to detect objects in the blind spot area of 324. These findings indicate that risk control needs to be focused on driver conditions and driving behavior, while paying attention to the effectiveness of supervision and the company's safety system.

The integration of HFACS and FMEA provides complementary analysis results, namely HFACS is used to identify and classify accident-causing factors, while FMEA is used to determine risk priorities based on severity, likelihood of occurrence, and detectability. Based on these results, recommendations for improvement include the implementation of fatigue management, work and rest time arrangements, defensive driving training, increased understanding of blind spots, optimization of driving behavior monitoring through GPS and telematics, and follow-up on repeated violations. Thus, the integration of both methods can be the basis for setting priorities for traffic accident risk control in a more systematic and comprehensive manner. However, the RPN values in this study are still based on assessment simulations, so validation through actual assessments with related parties is needed so that risk priorities and improvement recommendations can be implemented more accurately.

REFERENCE

[1] MN Fauzan, L. Yuliana, D. Adhitama, and I. Zulfikar, “Socialization of human error factors on mixer truck transportation safety using the HFACS approach at PT. XYZ,” EUNOIA: ***Jurnal Pengabdian Masyarakat,*** vol. 5, no. 1, pp. 12–20, 2026, doi: 10.36277/eunoia.v5i1.884.

[2] ENF Suwandi, B. Suhardi, and E. Muslimah, “Analysis of human error factors on the probability of accidents in bus drivers using the Human Factors Analysis and Classification System approach,” Ranah Research: ***Journal of Multidisciplinary Research and Development***, vol. 8, no. 4, 2026, doi: 10.38035/rrj.v8i4.2198.

[3] AF Musyaffa, MAFA, AAR Cindy, BR Hutabalian, and BS Nugroho, "Analysis of occupational accident causes using the Human Factor Analysis and Classification System method in the coal industry, West Virginia," ***Jurnal Migasian***, vol. 8, no. 2, 2024.
[4] D. Kurniasih, A. Maharani, and ML Ashari, "Human Factors Analysis and Classification System (HFACS) on accidents due to tilting ships," ***Indonesian Journal of Innovation Multidisciplinary Research***, vol. 2, no. 2, 2024, doi: 10.69693/ijim.v2i2.134.
[5] IZ Sutalaksana, "Preliminary study of occupational safety systems in accident cases at SBU ITS PT. X using the Human Factors Analysis and Classification System (HFACS) methodology," ***Journal of Ergonomics and K3***, vol. 3, no. 1, pp. 11–17, 2018, doi: 10.5614/j.ergo.2018.3.1.3.
[6] W. Budiawan and H. Iridiastadi, "Designing a computer aided system to analyze human error in Indonesian railways," J@TI Undip: ***Jurnal Teknik Industri,*** vol. 8, no. 2, p. 89, 2013, doi: 10.12777/jati.8.2.89-89.
[7] B. Mardikawati, DO Mulyaningtyas, and Y. Fitasari, "Analysis of the contribution of human error to traffic accidents in Bali: A mixed-method approach with convergent triangulation design," ***Journal of Road Transportation Safety***, vol. 12, no. 1, pp. 47–57, 2025, doi: 10.46447/ktj.v12i1.693.
[8] FV Rahmadani and BYS Nugroho, "The relationship between driving hours, blood pressure, and driving aggressiveness with fatigue in AKDP bus drivers: A cross-sectional study," ***Journal of Road Transportation Safety***, vol. 13, no. 1, pp. 1–14, 2026, doi: 10.46447/ktj.v13i1.779.
[9] MLS Zainy, GB Pratama, RR Kurnianto, and H. Iridiastadi, "Fatigue among Indonesian commercial vehicle drivers: A study examining changes in subjective responses and ocular indicators," ***International Journal of Technology***, vol. 14, no. 5, pp. 1039–1048, 2023, doi: 10.14716/ijtech.v14i5.4856.
[10] R. Zuraida and BS Abbas, "The factors influencing fatigue related to the accident of intercity bus drivers in Indonesia," ***International Journal of Technology***, vol. 11, no. 2, pp. 342–352, 2020, doi: 10.14716/ijtech.v11i2.3792.
[11] E. Purwanto, H. Hidayat, and E. Pranoto, "Fatigue levels in Trans Semarang and Trans Jateng Bus Rapid Transit (BRT) drivers," ***Journal of Road Transportation Safety,*** vol. 5, no. 2, pp. 53–64, 2018, doi: 10.46447/ktj.v5i2.49.
[12] R. Aprianto, A. Rokhim, A. Basuki, and Sugiyarto, "The Effect of Driver Characteristics and Rest Area Utilization on Driver Fatigue: A Case Study of the Pejagan–Solo Toll Road," ***Journal of Road Transportation Safety,*** vol. 8, no. 1, pp. 92–103, 2021, doi: 10.46447/ktj.v8i1.310.
[13] AA Mauludi, Z. Djunaidi, and LS Arif, "Risky behavior as a causal factor in accidents among commercial motorcycle drivers: A systematic review," ***Journal of Road Transportation Safety***, vol. 8, no. 1, pp. 12–25, 2021.
[14] G. Guritnaningsih, T. Tjahjono, and D. Maulina, "Human error in traffic accidents: Analysis based on information processing," ***Journal of Indonesia Road Safety***, vol. 1, no. 1, 2018, doi: 10.19184/korlantas-jirs.v1i1.14772.
[15] YYN Adlina and S. Nurlaela, "Analysis of traffic accident factors in Surabaya based on spatial planning perspective through spatial modeling," ***Jurnal Teknik ITS***, vol. 10, no. 1, pp. E13–E20, 2021, doi: 10.12962/j23373539.v10i1.59782.
[16] D. Kusmayadi and U. Fariz, "Identification of accident-prone locations (blackspots) in Bekasi Regency," ***Journal of Road Transportation Safety***, vol. 10, no. 1, 2023, doi: 10.46447/ktj.v10i1.520.
[17] IB Prastiyo, "Analysis of traffic accident incidence and costs (case study of Jambi City)," ***Journal of Road Transportation Safety***, vol. 10, no. 2, 2023, doi: 10.46447/ktj.v10i2.561.
[18] EAT Aji, R. Firdaus, C. Sanggalangi, and MR Irfani, "Analysis of accident-prone areas on the Becakayu Toll Road using the Equivalent Accident Number (EAN) method," ***Journal of Road Transportation Safety***, vol. 11, no. 1, 2024, doi: 10.46447/ktj.v11i1.575.
[19] S. Hadi, SI Wahyudi, K. Wibowo, Y. Oktopianto, AE Fahmadi, and IW Anggraeni, "Analysis of accident-prone locations on flat and hilly roads," ***Journal of Road Transportation Safety***, vol. 12, no. 1, pp. 36–46, 2025, doi: 10.46447/ktj.v12i1.686.
[20] B. Imawan, ED Priyana, and YP Nugroho, "Analysis of occupational accident risks in PT. XYZ workshop using the Failure Mode and Effect Analysis method," SIGMA TEKNIKA, vol. 6, no. 1, 2023.
[21] H. Hardiansah, Y. Sukmono, and WWE Saptaningtyas, "Analysis of occupational accident risks using the Failure Mode and Effect Analysis (FMEA) and Fault Tree Analysis (FTA) methods: A case study of the Dynamic Workshop," ***Jurnal Teknik Industri (JATRI)***, vol. 1, no. 1, pp. 1–9, 2023, doi: 10.30872/jatri.v1i1.493.
[22] VE Ateng, R. Rahmahwati, and YE Prawatya, "Proposed improvement of the OHS system using FMEA and RCA methods at PT. XYZ," ***Journal of Industrial Engineering, Tanjungpura University***, vol. 5, no. 1, 2021.
[23] MF Kurnianto, Kusnadi, and FN Azizah, "Proposed improvement of occupational accident risk using Failure Mode and Effect Analysis (FMEA) and Fishbone Diagram methods," ***SELAPARANG: Jurnal Pengabdian Masyarakat Berkemajuan***, vol. 6, no. 1, 2022, doi: 10.31764/jpmb.v6i1.6627.
[24] MAY Verdiansyah and AW Rizqi, "Analysis of work accidents at PT Ravana Jaya using FMEA and FTA methods," ***INTECOMS: Journal of Information Technology and Computer Science***, vol. 8, no. 6, pp. 2008–2013, 2025, doi: 10.31539/pe4p8324.
[25] GAB Fadillah, YH Haerudin, and RF Ramdhani, "Occupational safety risk analysis using Job Safety Analysis

(JSA) and Failure Mode and Effects Analysis (FMEA) methods in the waste processing process at CV. Dea Ayu Lestari Purwakarta," ***Journal of School Leadership and Management***, vol. 11, no. 4, 2026, doi: 10.34125/jkps.v11i4.3196