

Organizational Climate, Job Safety Analysis, and Crew Safety Behavior for Barito River Collision Prevention

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Abstract—The Barito River navigation channel is characterized by dense traffic and dynamic river conditions that increase the risk of ship collision. Internal incident data from PT XXX recorded 135 ship accidents during 2023–2025, with collision ranking as the second largest category after grounding. This study analyzes the influence of organizational climate and Job Safety Analysis (JSA) implementation on crew safety behavior and their implications for collision prevention in the Barito River channel. A descriptive quantitative approach was applied using a closed-ended questionnaire distributed to 200 crew members operating tug and barge vessels and 5 port captains, with data analyzed through SEM-PLS. To complement the quantitative findings, a real-case assessment test involving five Port Captains was conducted using a realistic collision scenario. The results show that JSA implementation has a positive and significant effect on safety behavior and collision prevention, while safety behavior also has a positive and significant effect on collision prevention. Organizational climate shows a positive but statistically insignificant effect on safety behavior, while its direct effect on collision prevention is negative and significant. The model explains 64.7% of the variance in safety behavior and 62.1% of the variance in collision prevention, with both endogenous constructs also showing predictive relevance. The real-case assessment confirms that lookout quality, communication, role clarity, and pre-operational risk control are critical factors in preventing collisions in narrow river navigation. These findings highlight the importance of strengthening JSA practice and safe operational behavior to improve navigation safety in the Barito River channel.

Keywords—Barito River; Collision Prevention; Job Safety Analysis; Organizational Climate; Safety Behavior.

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I. INTRODUCTION

Indonesia, has 214 navigable rivers out of approximately 2,300 rivers with the potential to serve as logistics transportation routes for both traditional communities and industrial activities. River-based logistics routes or inland waterways, most of which are located on Kalimantan Island, are more economical, more efficient, and lower in emissions than land-based transportation modes [1]. One of the most important inland waterways is the Barito River, which has a channel length of 780 km, a width ranging from 200 to 650 m, and a depth of up to 7 m. The Barito River serves as a strategic logistics corridor for coal transportation companies in Central Kalimantan Province, particularly in areas that are difficult to access by land infrastructure. One of the companies holding a concession for managing this waterway is PT XXX, which operates a fleet of tug and barge units with capacities ranging from 4,000 to 5,500 tons.

However, despite its strategic role as a logistics route, the high intensity of vessel traffic and dynamic river conditions make the Barito River channel vulnerable to various shipping accidents. Based on PT XXX internal data for the period 2023–2025, a total of 135 ship accidents were recorded, with the distribution of causes shown in Fig. 1, namely 53.33% (72 cases) grounding, 35.56% (48 cases) collision, 0.74% (1 case) lost time accident (LTI), 1.48% (2 cases) minor injury, 0.74% (1 case) fatality, and 8.15% (11 cases) other incidents [2]. This pattern is consistent with recent evidence from Indonesian tug-and-barge operations, where human factors were identified as the dominant accident cause and became the highest priority for mitigation in vessel operation safety [3].

Although grounding accounted for more than 50% of the total incidents, most of these events were associated with natural factors, particularly the lowering of the Barito River water level due to high sedimentation. In contrast, collision incidents were more closely related to human factors and tended to increase along with the intensity of shipping operations, as indicated by the increase in annual cycle time.

As shown in Fig. 2, the probability of operational failure due to collision increased from 0.82% in 2023 to 1.58% in 2024, before declining to 1.15% in 2025. Although the probability decreased in the final year, the value remained higher than the initial condition, indicating that the escalation of shipping activity increased risk exposure that was not fully offset by the effectiveness of safety controls [2].

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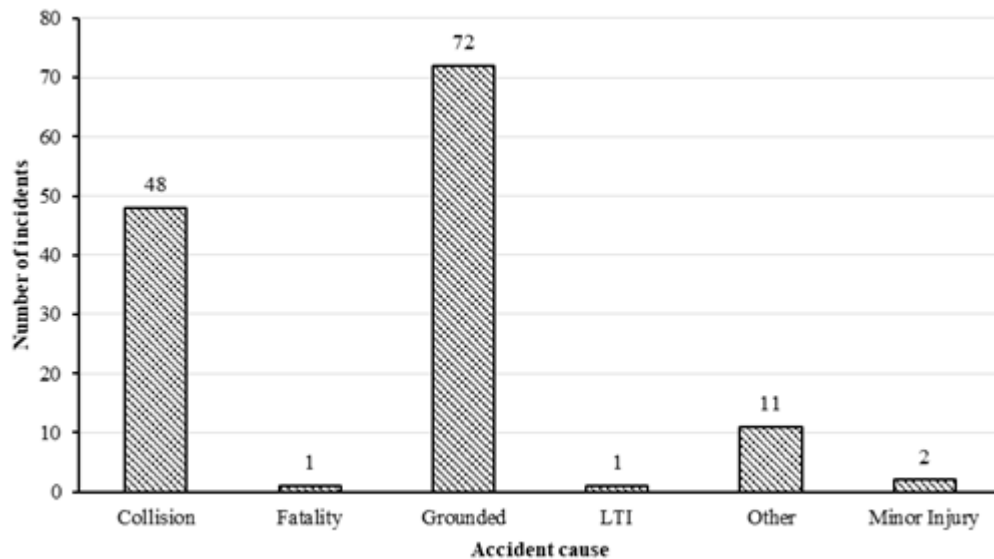


Figure 1. Causes of PT XXX ship accidents in the Barito River channel [2]

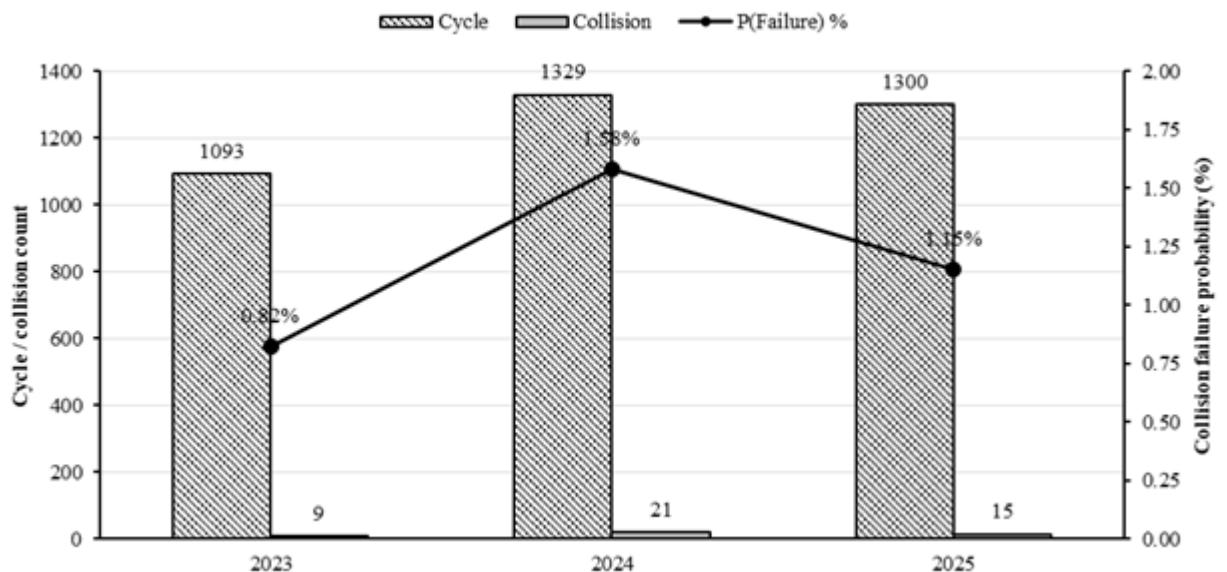


Figure 2. Collision probability and operational cycle in 2023-2025 [2]

Based on these conditions, the human factors can be understood as one of the key contributors to ship accidents in the Barito River channel. Previous studies emphasized that human factors repeatedly emerge as triggers of accidents through unsafe actions, such as communication failure, decision-making errors, teamwork problems, and weak situational awareness in dynamic situations [4], [5]. From the perspective of behavioral theory, safety behavior tends to be more consistent when individuals have a strong intention to act safely and perceive that they are able to control their actions, which is influenced by attitudes, prevailing social norms, and perceived behavioral control [6]. In the context of the Barito River channel, unsafe conditions associated with ship accidents can be grouped into five categories, which are maneuvering ability, miscommunication, negligence, understanding of regulations, and navigational ability, as shown in Fig. 3. Therefore, the safety behavior of ship crews can be

viewed as having an important relationship with efforts to prevent ship collisions in the channel.

As shown in Fig. 3, unsafe conditions in the form of miscommunication (36 cases) and negligence (28 cases) may indicate problems in the organizational climate, as both reflect recurring work patterns rather than purely random events. In shipping operations, organizational climate may be understood as the shared meaning formed by perceived policies, practices, and procedures, which helps explain differences in behavioral patterns and performance across work units, even when they perform similar tasks [7], [8], [9]. Bowen and Ostroff (2004) argued that climate clarity is also shaped by its strength, namely when organizational signals are perceived as clear, consistent, and widely shared, thereby reducing ambiguity in decision-making and increasing uniformity in work practices under risky conditions [10]. In the maritime context, crew perceptions of safety management can be measured through surveys and

reflected in managerial aspects as well as onboard work practices [11], [12]. Its relationship with safety behavior at the levels of compliance and participation further

suggests that strong organizational signals may encourage more consistent safe work habits [13].

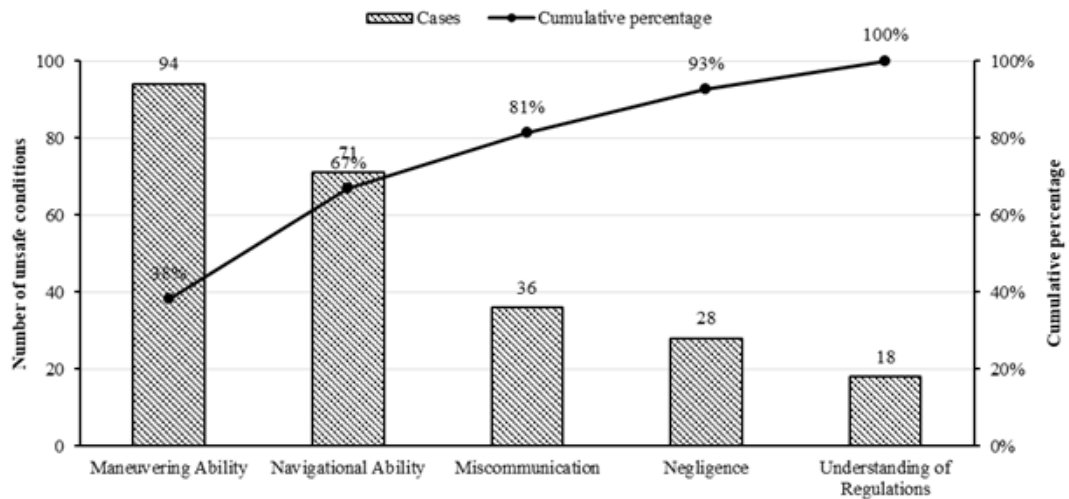


Figure 3. Unsafe conditions causing ship incidents in the Barito River channel [2]

In addition to organizational factors, miscommunication, crew negligence, and poor understanding of navigation rules also highlight the importance of job-based risk management through Job Safety Analysis (JSA). JSA, or Job Hazard Analysis, is understood as a systematic process of breaking work down into steps, identifying hazards at each step, and determining control measures before the work is carried out [14]. In narrow and dynamic river navigation operations, this approach is relevant for mapping risks arising from channel limitations, current conditions, changing situations, and the presence of obstacles into more measurable operational scenarios. These risks can then be managed through briefings, role allocation, operational limits, and clear mitigation measures, while also supporting safe navigation practices in tug-and-barge operations.

Recent studies have also shown that human error remains a dominant factor in many maritime accidents [15], [16]. In restricted waters, collision prevention requires anticipatory decision-making, effective communication, risk awareness, and compliance with navigation procedures [17], [18]. Broader reviews of maritime transport risk assessment also indicate that accident prevention requires methods capable of linking operational risk factors, human performance, and safety management practices [19].

However, previous studies have generally examined maritime accident causation, safety climate, JSA, safety behavior, or collision risk assessment separately. Limited empirical studies have integrated organizational climate, task-based JSA implementation, crew safety behavior, and ship collision prevention into one model, especially in tug-and-barge operations within narrow inland waterways such as the Barito River channel. In addition, many studies rely mainly on statistical survey analysis without comparing the findings with operational judgment from practitioners who directly manage vessel movement and safety control in the field. Therefore, the

novelty of this study lies in the development of an empirical collision-prevention model that integrates organizational climate, JSA implementation, crew safety behavior, and ship collision prevention, while combining SEM-PLS analysis with a real-case assessment test based on an actual collision scenario. This study aims to examine the effects of organizational climate and JSA implementation on crew safety behavior and ship collision prevention, as well as the contribution of safety behavior to collision prevention. The findings are expected to provide theoretical, empirical, and practical contributions by linking organizational, behavioral, and task-based risk-control factors to support data-driven safety improvement strategies for narrow river navigation.

II. METHOD

This study examines the effects of organizational climate (X1) and Job Safety Analysis (JSA) implementation (X2) as independent variables on crew safety behavior (Y) as an intervening variable, as well as their implications for ship collision prevention in the Barito River channel (Z) as the dependent variable. The study proposes seven hypotheses: the effects of organizational climate on safety behavior (H1) and collision prevention (H4); the effects of JSA implementation on safety behavior (H2) and collision prevention (H5); the effect of safety behavior on collision prevention (H6); the simultaneous effects of organizational climate and JSA implementation on safety behavior (H3); and the simultaneous effects of organizational climate, JSA implementation, and safety behavior on collision prevention (H7). The direct effects were assessed using path coefficients and bootstrapping results, while the simultaneous effects were assessed using the explanatory power of the endogenous constructs. The conceptual model and the hypothesized relationships are presented in Fig. 4.

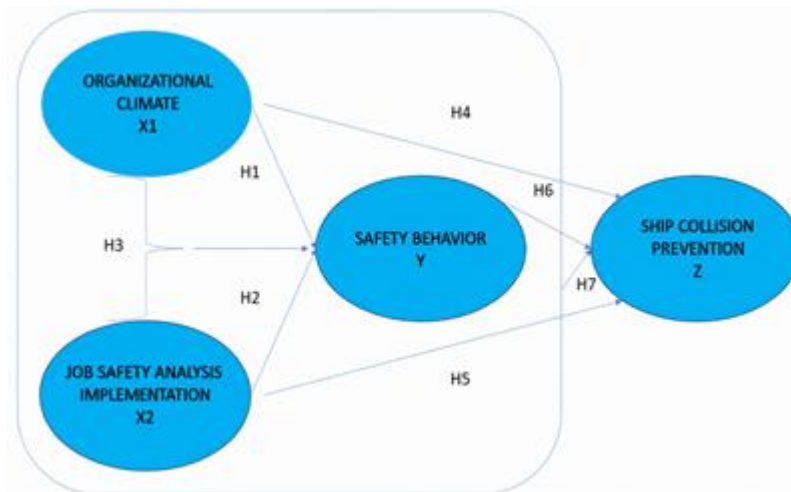


Figure 4. Relationships between variables

This study employed a descriptive quantitative method using a survey approach involving crew members operating PT XXX's tug and barge fleet in the Barito River channel. The total population consisted of 205 respondents, including 200 crew members and five Port Captains. Because the entire population was included, this study applied a total sampling technique. Data were collected through a closed-ended questionnaire using a Likert scale distributed via Google Forms from March 17 to March 23, 2026. The questionnaire data were analyzed using SmartPLS with the PLS-SEM approach, which is suitable for prediction-oriented research involving complex structural models and does not require multivariate normal data distribution [20].

To complement the quantitative findings, this study also employed a real-case assessment test involving five Port Captains to evaluate respondents' ability to conduct critical assessments and respond to realistic incident scenarios. The assessment responses were analyzed

descriptively and qualitatively, and then synthesized into the aspects of safety behavior, JSA implementation, and organizational climate.

In this assessment, respondents were asked to identify unsafe conditions, determine possible causal factors, relate the case to relevant collision-prevention principles, and prepare simplified JSA-based control measures for critical navigation stages. The responses were then grouped according to key operational aspects, including lookout, communication, role allocation, route and current assessment, speed control, maneuvering decisions, and work-rest management. This procedure was used to compare the SEM-PLS findings with operational judgment from practitioners who directly manage tug-and-barge navigation safety in the Barito River channel.

The questionnaire data were validated through outer model evaluation, which included convergent validity, discriminant validity, and construct reliability, using the minimum criteria shown in Table 1 [20], [21], [22].

TABLE 1.
MINIMUM STANDARDS FOR OUTER MODEL EVALUATION

Evaluation Criterion	Threshold
Convergent Validity	Loading Factor > 0.7
	Average Variance Extracted (AVE) > 0.5
Discriminant Validity	Square root of AVE is greater than inter-construct correlations
	Indicator/dimension loading is highest on its intended construct
	Heterotrait-Monotrait Ratio of Correlations (HTMT) < 0.90
Construct Reliability	Cronbach's Alpha > 0.7
	Composite Reliability > 0.7
	$\rho_A > 0.70$

In this study, variables X1, X2, Y, and Z were treated as multidimensional constructs; therefore, measurement model evaluation was conducted at two levels, namely first-order and second-order. In PLS-SEM, such multilevel constructs are referred to as higher-order constructs or hierarchical component models [22], [23]. At the first-order level, the evaluation assesses the relationships between indicators and the dimensions they represent, whereas at the second-order level, it assesses the relationships between dimensions and their higher-level latent constructs. This approach is used when a more abstract construct is represented by several more

concrete and interrelated dimensions, and it can be evaluated using either the repeated indicators approach or the two-stage approach, while still applying appropriate measurement criteria at each construct level [21].

III. RESULTS

A. Respondent Demographics

Figure 5 presents the demographic profile of respondents based on age group, educational background, service years, and job position.

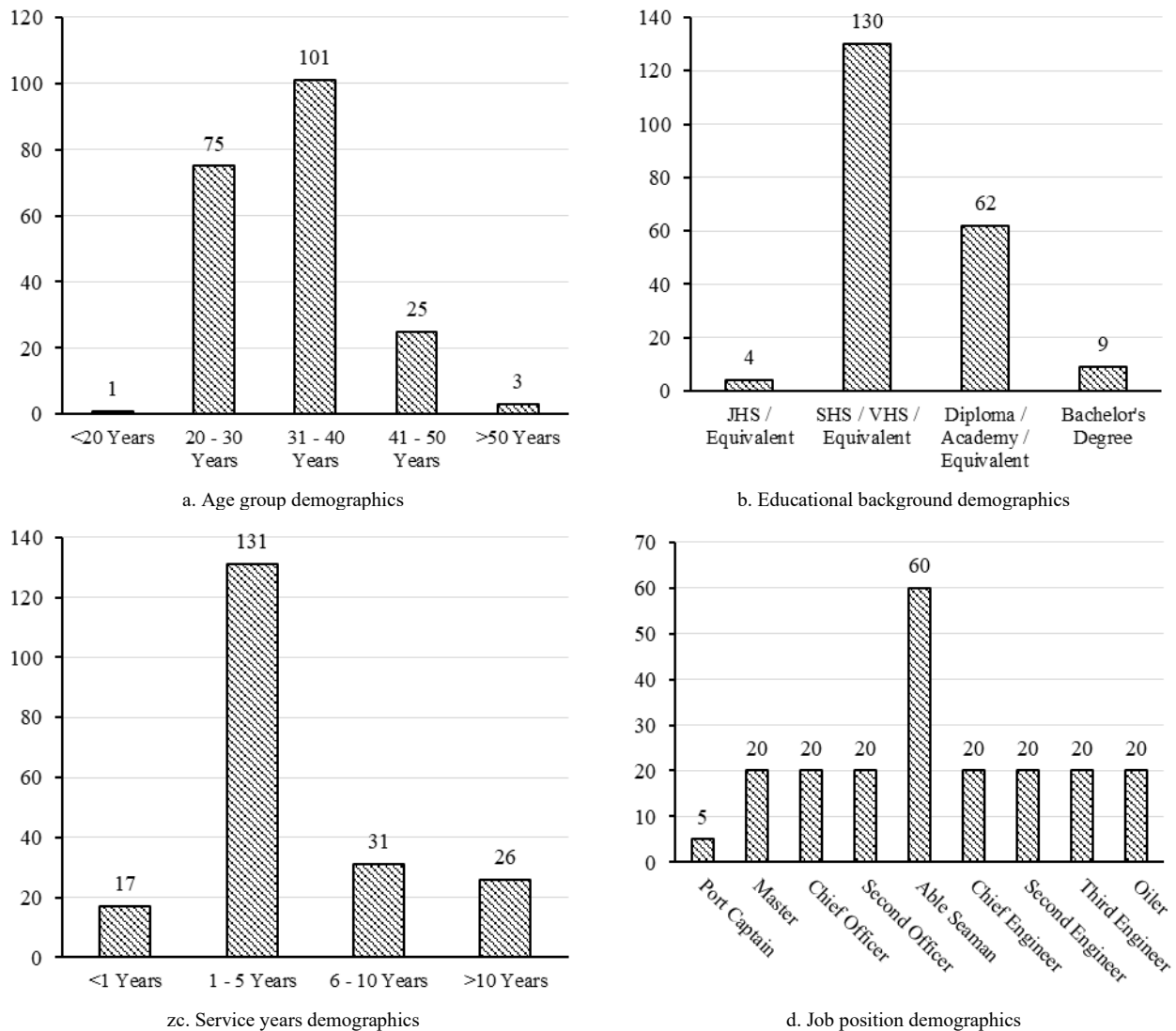


Figure 5. Demographic profile of respondents

Based on Fig. 5, the respondents were predominantly in the productive working-age group, with most respondents aged 31 – 40 years, followed by the 20 – 30 years age group. The educational background was dominated by SHS/VHS/equivalent graduates, followed by diploma/academy/equivalent graduates. In terms of service years, most respondents had 1 – 5 years of experience at PT XXX, indicating that the sample mainly represented active operational personnel involved in daily tug-and-barge activities. The job-position distribution also shows that the respondents covered both deck and engine departments, with Able Seaman as the largest group and Port Captains included to provide supervisory and operational safety perspectives. Therefore, the respondent profile is considered relevant

for assessing safety behavior, JSA implementation, and collision-prevention practices in Barito River navigation.

B. Measurement Model Analysis (Outer Model)

Figure 6 presents the first-order measurement model through the outer loading values between indicators and their respective dimensions, whereas Fig. 7 presents the second-order measurement model through the relationships between dimensions and their higher-order latent constructs.

Convergent validity was assessed using loading factor values at both the first-order and second-order levels, as well as the Average Variance Extracted (AVE), which indicates the extent to which the indicators represent the latent variables. Table 2 presents the loading factor values, while Table 3 presents the AVE values for each latent variable.

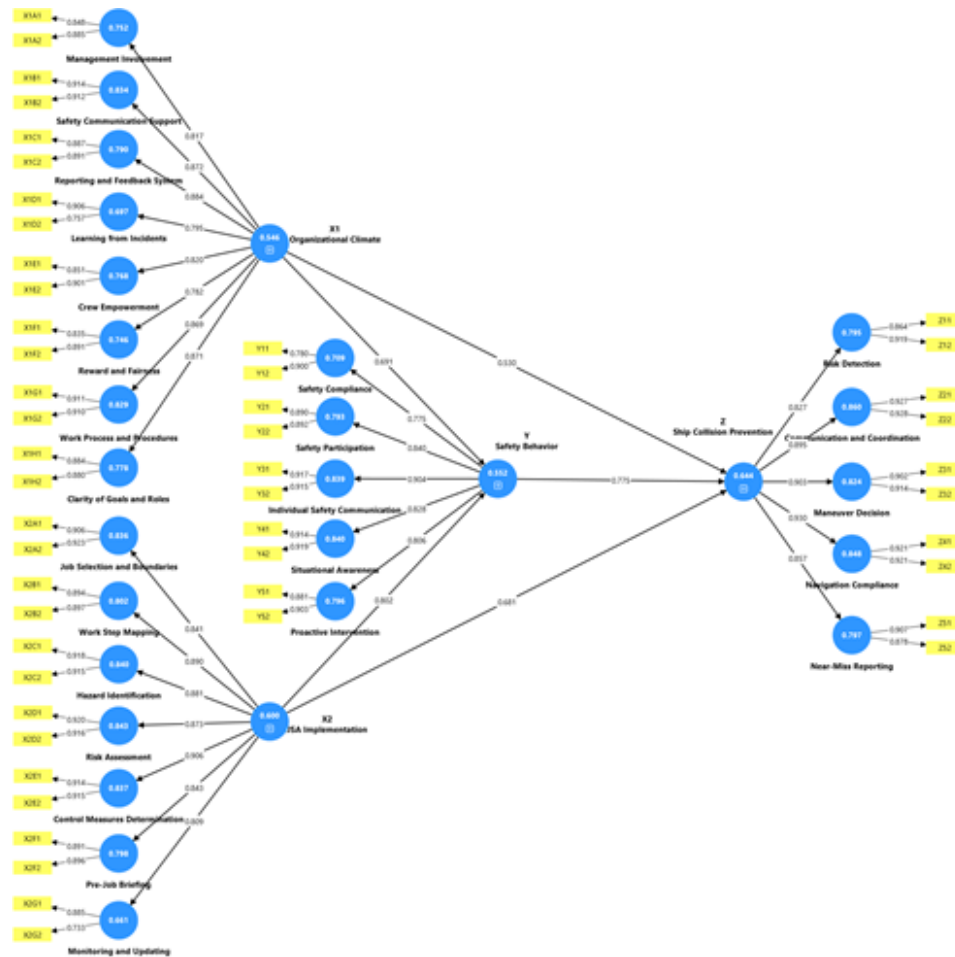


Figure 7. Second-order measurement model (outer model)

TABLE 2.
FIRST-ORDER AND SECOND-ORDER LOADING FACTOR VALUES

Variable	Dimension	Second - Order Dimension Loading Factor	Indicator	First - Order Indicator Loading Factor	Decision
(X1) Organizational Climate	Management Involvement	0.814	X1A1	0.848	Valid
			X1A2	0.885	
	Safety Communication Support	0.865	X1B1	0.914	
			X1B2	0.912	
	Reporting and Feedback System	0.879	X1C1	0.887	
			X1C2	0.891	
	Learning from Incidents	0.800	X1D1	0.906	
			X1D2	0.757	
	Crew Empowerment	0.823	X1E1	0.851	
			X1E2	0.901	
(X2) JSA Implementation	Reward and Fairness	0.786	X1F1	0.835	Valid
			X1F2	0.891	
	Work Process and Procedures	0.867	X1G1	0.911	
			X1G2	0.910	
	Clarity of Goals and Roles	0.876	X1H1	0.884	
			X1H2	0.880	
	Job Selection and Boundaries	0.835	X2A1	0.906	
			X2A2	0.923	
	Work Step Mapping	0.890	X2B1	0.894	
			X2B2	0.897	
	Hazard Identification	0.879	X2C1	0.918	
			X2C2	0.915	
	Risk Assessment	0.870	X2D1	0.920	
			X2D2	0.916	
	Control Measures Determination	0.905	X2E1	0.914	
			X2E2	0.915	
	Pre-Job Briefing	0.845	X2F1	0.891	
			X2F2	0.896	
	Monitoring and Updating	0.820	X2G1	0.885	
			X2G2	0.733	

CONTINUED TABLE 2.
FIRST-ORDER AND SECOND-ORDER LOADING FACTOR VALUES

Variable	Dimension	Second - Order Dimension Loading Factor	Indicator	First - Order Indicator Loading Factor	Decision
(Y) Safety Behavior	Safety Compliance	0.783	Y11	0.780	Valid
			Y12	0.900	
	Safety Participation	0.843	Y21	0.890	
			Y22	0.892	
	Individual Safety Communication	0.899	Y31	0.917	
			Y32	0.915	
	Situational Awareness	0.825	Y41	0.914	
			Y42	0.919	
(Z) Ship Collision Prevention	Proactive Intervention	0.805	Y51	0.881	Valid
			Y52	0.903	
	Risk Detection	0.836	Z11	0.864	
			Z12	0.919	
	Communication and Coordination	0.891	Z21	0.927	
			Z22	0.928	
	Maneuver Decision	0.898	Z31	0.902	
			Z32	0.914	
	Navigation Compliance	0.928	Z41	0.921	
			Z42	0.921	
	Near-Miss Reporting	0.860	Z51	0.907	
			Z52	0.878	

TABLE 3.
AVERAGE VARIANCE EXTRACTED (AVE) VALUES

Variable	Average Variance Extracted (AVE)	Decision
(X1) Organizational Climate	0.705	Valid
(X2) JSA Implementation	0.746	Valid
(Y) Safety Behavior	0.692	Valid
(Z) Ship Collision Prevention	0.78	Valid

Overall, the results in Table 2 show that all loading factor values, at both the first-order and second-order levels, are above 0.70, indicating that all indicators and dimensions in the model are valid. In addition, based on Table 3, all variables have AVE values greater than 0.50, indicating that they meet the convergent validity criterion.

Discriminant validity was also assessed using the Fornell-Larcker Criterion, cross-loading values, and the Heterotrait-Monotrait Ratio (HTMT). The Fornell-

Larcker Criterion compares the square root of AVE for each construct with its correlations with other constructs, while cross-loading values assess whether each dimension loads highest on its corresponding higher-order latent variable. HTMT was used to evaluate the degree of similarity between constructs in the model [23].

These results are presented in Table 4, Table 5, and Table 6.

TABLE 4.
FORNELL-LARCKER CRITERION VALUES AMONG VARIABLES

	(X1) Organizational Climate	(X2) JSA Implementation	(Y) Safety Behavior	(Z) Ship Collision Prevention
(X1) Organizational Climate	0.840	-	-	-
(X2) JSA Implementation	0.819	0.864	-	-
(Y) Safety Behavior	0.694	0.802	0.832	-
(Z) Ship Collision Prevention	0.535	0.683	0.777	0.883

TABLE 5.
CROSS-LOADING VALUES AMONG LATENT VARIABLES AND DIMENSIONS

Dimension	(X1) Organizational Climate	(X2) JSA Implementation	(Y) Safety Behavior	(Z) Ship Collision Prevention
(X1A) Management Involvement	0.814	0.626	0.535	0.451
(X1B) Safety Communication Support	0.865	0.691	0.556	0.43
(X1C) Reporting and Feedback System	0.879	0.719	0.577	0.425
(X1D) Learning from Incidents	0.8	0.626	0.558	0.382
(X1E) Crew Empowerment	0.823	0.65	0.606	0.399
(X1F) Reward and Fairness	0.786	0.681	0.553	0.427
(X1G) Work Process and Procedures	0.867	0.764	0.602	0.518
(X1H) Clarity of Goals and Roles	0.876	0.727	0.658	0.537
(X2A) Job Selection and Boundaries	0.688	0.835	0.668	0.526
(X2B) Work Step Mapping	0.768	0.89	0.711	0.618
(X2C) Hazard Identification	0.706	0.879	0.706	0.608

CONTINUED TABLE 5.
CROSS-LOADING VALUES AMONG LATENT VARIABLES AND DIMENSIONS

Dimension	(X1) Organizational Climate	(X2) JSA Implementation	(Y) Safety Behavior	(Z) Ship Collision Prevention
(X2D) Risk Assessment	0.681	0.87	0.691	0.604
(X2E) Control Measures Determination	0.732	0.905	0.725	0.658
(X2F) Pre-Job Briefing	0.683	0.845	0.689	0.564
(X2G) Monitoring and Updating	0.691	0.82	0.657	0.543
(Y1) Safety Compliance	0.552	0.611	0.783	0.556
(Y2) Safety Participation	0.618	0.695	0.843	0.648
(Y3) Individual Safety Communication	0.625	0.725	0.899	0.679
(Y4) Situational Awareness	0.52	0.636	0.825	0.741
(Y5) Proactive Intervention	0.57	0.663	0.805	0.594
(Z1) Risk Detection	0.503	0.615	0.709	0.836
(Z2) Communication and Coordination	0.462	0.621	0.667	0.891
(Z3) Maneuver Decision	0.412	0.533	0.645	0.898
(Z4) Navigation Compliance	0.496	0.623	0.719	0.928
(Z5) Near-Miss Reporting	0.481	0.616	0.684	0.86

TABLE 6.
HETEROTRAIT-MONOTRAIT RATIO (HTMT) VALUES

	(X1) Organizational Climate	(X2) JSA Implementation	(Y) Safety Behavior	(Z) Ship Collision Prevention
(X1) Organizational Climate	-	-	-	-
(X2) JSA Implementation	0.868	-	-	-
(Y) Safety Behavior	0.758	0.876	-	-
(Z) Ship Collision Prevention	0.567	0.727	0.851	-

Based on Table 4, the diagonal values for each construct, namely 0.840 for (X1) Organizational Climate, 0.864 for (X2) JSA Implementation, 0.832 for (Y) Safety Behavior, and 0.883 for (Z) Ship Collision Prevention, are all greater than the correlations with other constructs. These results indicate that each variable has good ability to distinguish itself from the other variables in the model, meaning that the discriminant validity criterion based on the Fornell-Larcker Criterion has been satisfied. In addition, based on Table 5, all dimensions show the highest loading values on their respective latent variables. This indicates that, at the

second-order level, each dimension is better able to represent its corresponding higher-order latent construct than the other latent variables. This result is further supported by the HTMT values, all of which remain below the common threshold of 0.90, indicating that the constructs can be adequately distinguished from one another and therefore meet the discriminant validity criterion.

Reliability testing was conducted to determine whether the variables used in this study were reliable. Reliability was assessed using Cronbach's alpha and composite reliability, as presented in Table 7.

TABLE 7.
CONSTRUCT RELIABILITY TESTING

	Cronbach's alpha	Composite Reliability (rho_a)	Composite Reliability (rho_c)
(X1) Organizational Climate	0.94	0.943	0.95
(X2) JSA Implementation	0.943	0.945	0.954
(Y) Safety Behavior	0.888	0.892	0.918
(Z) Ship Collision Prevention	0.929	0.93	0.947

Based on Table 7, all constructs meet the reliability criterion. This is indicated by the Cronbach's alpha and composite reliability values obtained from the SmartPLS estimation results, all of which are greater than 0.70, as recommended by the established criteria.

C. Structural Model Analysis (Inner Model)

The structural model, or inner model, was evaluated to examine the relationships among the latent constructs in this study. This analysis aims to assess the ability of

the exogenous constructs to explain the endogenous constructs, as well as to test the direction and significance of the relationships among variables in the model. The inner model evaluation was conducted by examining the R-square, Q² predict, path coefficients, and the t-statistics and p-values obtained through the

bootstrapping procedure. Fig. 8 presents the second-order inner model used to test the relationships among the latent variables.

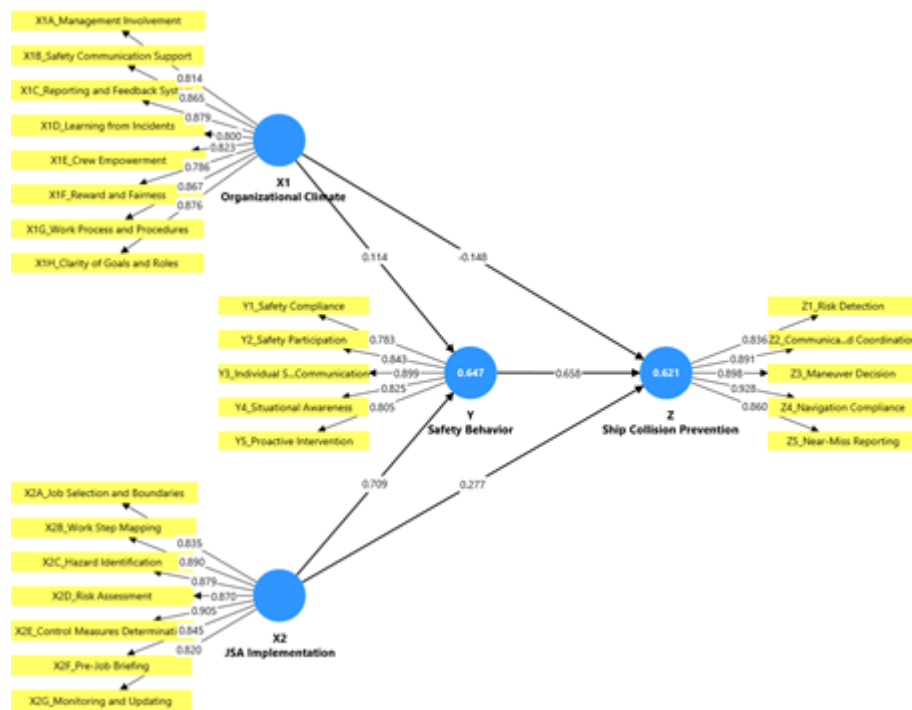


Figure 8. Structural model (inner model)

Methodologically, R^2 is used to assess the extent to which endogenous constructs can be explained by exogenous constructs in the model, whereas Q^2 predict from PLSpredict is used to evaluate predictive relevance, or the predictive capability of the model on data outside the training sample. A Q^2 predict value greater than 0

indicates that the PLS model has better predictive performance than a simple mean-based prediction [24]. In PLS-SEM, the general interpretation of R^2 values is 0.25 (weak), 0.50 (moderate), and 0.75 (substantial). Table 8 presents the R-square (R^2) and Q^2 predict values.

TABLE 8.
 R^2 AND Q^2 PREDICT VALUES

	R^2	R^2 adjusted	Q^2 predict
(Y) Safety Behavior	0.647	0.644	0.62
(Z) Ship Collision Prevention	0.621	0.615	0.451

The R^2 value for Safety Behavior (Y) is 0.647, with an adjusted R^2 of 0.644, indicating that Organizational Climate (X1) and JSA Implementation (X2) explain 64.7% of the variance in Safety Behavior, while the remaining 35.3% is influenced by other factors outside the model. Meanwhile, the R^2 value for Ship Collision Prevention (Z) is 0.621, with an adjusted R^2 of 0.615, indicating that Organizational Climate (X1), JSA Implementation (X2), and Safety Behavior (Y) explain 62.1% of the variance in Ship Collision Prevention, while the remaining 37.9% is explained by other factors outside the model. These values indicate that the model has adequate explanatory power. In addition, the Q^2 predict values of 0.620 for Safety Behavior (Y) and

0.451 for Ship Collision Prevention (Z), both of which are greater than 0, indicate that the model has predictive relevance. Thus, the model not only explains the relationships among constructs, but also demonstrates predictive capability for the endogenous constructs under study.

Path coefficient testing was conducted to examine the direction and magnitude of the direct effects among the latent variables in the structural model. These values indicate whether the relationships among constructs are positive or negative, and they also show the strength of the direct effect of an exogenous variable on an endogenous variable. Table 9 presents the path coefficient values for each latent variable.

TABLE 9.
PATH COEFFICIENT VALUES

	(X1) Organizational Climate	(X2) JSA Implementation	(Y) Safety Behavior	(Z) Ship Collision Prevention
(X1) Organizational Climate	-	-	0.114	-0.148
(X2) JSA Implementation	-	-	0.709	0.277
(Y) Safety Behavior	-	-	-	0.658
(Z) Ship Collision Prevention	-	-	-	-

Based on Table 9, Organizational Climate (X1) has a weak positive effect on Safety Behavior (Y) of 0.114 and

a weak negative effect on Ship Collision Prevention (Z) of -0.148. JSA Implementation (X2) shows the strongest

positive effect on Safety Behavior (Y), with a coefficient of 0.709, as well as a positive effect on Ship Collision Prevention (Z) of 0.277. Meanwhile, Safety Behavior (Y) has a moderately strong positive effect on Ship Collision Prevention (Z), with a coefficient of 0.658. Overall, JSA Implementation provides the largest direct contribution to Safety Behavior, whereas Safety Behavior contributes strongly to Ship Collision Prevention.

The t-statistics and p-values were tested to assess the significance of the relationships among latent variables

in the structural model. The t-statistic indicates the strength of statistical evidence for the estimated path coefficient, while the p-value indicates whether the relationship among latent variables is statistically significant at a given level of significance. Through bootstrapping, this test provides the basis for deciding whether the research hypotheses are supported. Table 10 presents the bootstrapping results for the t-statistics and p-values.

TABLE 10.
BOOTSTRAPPING RESULTS OF T-STATISTICS AND P-VALUES

Path	Original sample (O)	Sample mean (M)	Standard deviation (Stadev)	t-statistics	p-values	Interpretation Criteria
(X1) → (Y)	0.114	0.139	0.153	0.743	0.458	Not significant
(X1) → (Z)	-0.148	-0.148	0.069	2.154	0.031	Significant
(X2) → (Y)	0.709	0.681	0.127	5.603	0.000	Significant
(X2) → (Z)	0.277	0.276	0.097	2.852	0.004	Significant
(Y) → (Z)	0.658	0.658	0.074	8.857	0.000	Significant

The bootstrapping results show that the paths from JSA Implementation to Safety Behavior, JSA Implementation to Ship Collision Prevention, Safety Behavior to Ship Collision Prevention, and Organizational Climate to Ship Collision Prevention are statistically significant. However, the path from Organizational Climate to Safety Behavior is not statistically significant. Overall, the structural model results indicate that JSA implementation and safety behavior have stronger direct relationships with ship collision prevention than organizational climate. The significance testing results provide the basis for the hypothesis discussion presented in the following section.

IV. DISCUSSION

A. Hypothesis Testing

The following section discusses each hypothesis based on the structural model results presented in Table 8, Table 9, and Table 10. The discussion focuses not only on statistical significance, but also on the operational meaning of each relationship in the context of tug-and-barge navigation in the Barito River channel.

H1: Organizational climate affects safety behavior.

Based on Table 10, the effect of Organizational Climate (X1) on Safety Behavior (Y) has a coefficient of 0.114 with a positive direction, but it is not statistically significant because the t-statistic is $0.743 < 1.96$ and the p-value is $0.458 > 0.05$. Therefore, H1 is not supported. This finding indicates that organizational climate alone does not directly shape crew safety behavior unless it is translated into concrete operational routines. This is consistent with previous studies showing that safety climate influences behavior through safety knowledge, motivation, compliance, and participation [5], [9]. In the Indonesian maritime context, communication, supervision, competence, and safety culture are also considered important determinants of ship accident risk [25].

H2: Job Safety Analysis implementation affects safety behavior.

Based on Table 10, the effect of JSA Implementation (X2) on Safety Behavior (Y) has a coefficient of 0.709 and is statistically significant (t-statistic $5.603 > 1.96$; p-value < 0.05). Therefore, H2 is supported. This result shows that JSA directly supports safe behavior by guiding crews to identify hazards, conduct briefings, assign roles, and determine control measures before operations. This is in line with JSA as a job-based hazard identification process and with the concept of risk treatment in accident prevention [14], [26].

H3: Organizational climate and JSA implementation simultaneously affect safety behavior.

Based on Table 8, the R^2 value of Safety Behavior (Y) is 0.647, indicating that Organizational Climate (X1) and JSA Implementation (X2) jointly explain 64.7% of the variance in Safety Behavior. Therefore, H3 is supported based on the explanatory power of the model. This finding indicates that safety behavior is influenced by both organizational conditions and operational risk-control practices. However, the path coefficient shows that JSA implementation has a stronger direct contribution than organizational climate. This finding is also supported by Vinodkumar and Bhasi (2010), who found that safety management practices have direct and indirect relationships with safety compliance and safety participation through safety knowledge and safety motivation [27]. This indicates that safety behavior is not shaped by a single factor, but by the combined effect of organizational conditions and operational safety-management practices.

H4: Organizational climate affects ship collision prevention.

Based on Table 10, the effect of Organizational Climate (X1) on Ship Collision Prevention (Z) has a coefficient of -0.148 and is statistically significant (t-statistic $2.154 > 1.96$; p-value $0.031 < 0.05$). Therefore, H4 is statistically supported, but the relationship is negative. This result suggests that organizational climate does not automatically improve collision prevention when it is not converted into concrete bridge-team

behavior, communication, and risk-control actions. Similar maritime safety studies emphasize that accident risk is closely related to communication, supervision, safety culture, and human factors [16], [25].

H5: Job Safety Analysis implementation affects ship collision prevention.

Based on Table 10, the effect of JSA Implementation (X2) on Ship Collision Prevention (Z) has a coefficient of 0.277 and is statistically significant (t-statistic 2.852 > 1.96; p-value 0.004 < 0.05). Therefore, H5 is supported. This finding shows that JSA strengthens collision prevention through hazard identification, risk analysis, control planning, and pre-operational briefing. This is aligned with maritime risk assessment studies that emphasize hazard identification and control measures as important elements in accident prevention [28].

H6: Safety behavior affects ship collision prevention

Based on Table 10, the effect of Safety Behavior (Y) on Ship Collision Prevention (Z) has a coefficient of 0.658 and is statistically significant (t-statistic 8.857 > 1.96; p-value < 0.05). Therefore, H6 is supported. This finding indicates that safety behavior is the strongest direct factor in collision prevention. Procedural compliance, communication, watchkeeping vigilance, situational awareness, and safety participation are essential for detecting collision risk and taking preventive action [9], [16].

H7: Organizational climate, Job Safety Analysis implementation, and safety behavior simultaneously affect ship collision prevention

Based on Table 8, the R² value of Ship Collision Prevention (Z) is 0.621, indicating that Organizational Climate (X1), JSA Implementation (X2), and Safety Behavior (Y) jointly explain 62.1% of the variance in Ship Collision Prevention. Therefore, H7 is supported based on the explanatory power of the model. This finding confirms that ship collision prevention in the Barito River channel is influenced by a combination of organizational, procedural, and behavioral factors. However, the path coefficients show that safety behavior provides the strongest direct contribution to collision prevention, followed by JSA implementation. This finding strengthens previous research by Chauvin et al. (2013), which found that maritime collision accidents are shaped by human and organisational factors, including unsafe actions, supervision, operational preconditions, and organisational influences [29]. Therefore, collision prevention in narrow river navigation should not rely on a single factor, but should integrate organizational support, structured JSA implementation, and consistent crew safety behavior.

B. Real-Case Assessment Test

To complement the questionnaire data, a real-case assessment test based on a realistic work scenario was conducted to evaluate respondents' ability to identify appropriate risk-control measures. Five Port Captains were involved in this assessment, with the following characteristics:

TABLE 11.
CHARACTERISTICS OF REAL-CASE ASSESSMENT RESPONDENTS

Respondent	Age (Years)	Educational Background	Certification	Position	Service Years at PT XXX
Respondent 1	38	Diploma IV in Nautical Studies	ANT II	Port Captain	4 Years
Respondent 2	33	Senior High School / equivalent	ANT III	Port Captain	3 Years, 6 Months
Respondent 3	31	Diploma III	ANT III	Port Captain	4 Years
Respondent 4	34	Diploma IV in Nautical Studies	ANT-II	Port Captain	5 Years, 6 Months
Respondent 5	32	Diploma III	ANT-III	Port Captain	1 Year, 8 Months

The case study was derived from an actual incident involving a PT XXX tug-and-barge convoy that collided with a small vessel towing a gold-dredging raft while passing through a narrow bend in the Barito River channel, causing the gold-dredging raft to sink [30]. The causal analysis of the incident was then compared with the provisions of COLREG 1972, particularly the principles of lookout (Rule 5), safe speed (Rule 6), risk of collision (Rule 7), action to avoid collision (Rule 8), narrow channels (Rule 9), and warning signals (Rule 34), in order to relate the regulatory principles to the actual facts of the incident [31]. Figure 9 presents an illustration of the chronology of the incident.

Based on the results of the real-case assessment, all five respondents generally considered safety behavior, JSA implementation, and organizational climate to be closely related to the occurrence of the collision in the case analyzed. In terms of safety behavior, the respondents' answers showed a relatively consistent pattern, emphasizing the importance of lookout, active communication, gathering information before entering a bend, maintaining vigilance toward changing channel

conditions, and taking appropriate action when facing unsafe situations. Regarding JSA implementation, all respondents viewed JSA not merely as an administrative document, but as a practical tool for identifying hazards, assessing risks, and determining control measures before operations are carried out. Meanwhile, with respect to organizational climate, respondents emphasized the importance of clear role allocation, open communication, harmonious working relationships, and leadership that supports safety as factors that strengthen safe crew behavior.

In addition, the simplified JSA prepared by the five respondents showed a consistent pattern across work stages considered to have high risk, namely preparation before entering a bend, approaching the bend, maneuvering in critical areas, exiting the bend, and general operating conditions. The most frequently identified hazards included errors in route planning, inaccurate assessment of current conditions, ineffective communication, side currents, insufficient clearance from the riverbank, loss of steering response, limited visibility, and crew fatigue. The most frequently

proposed control measures included maneuver briefings, evaluation of current and water level conditions, speed reduction, additional lookout, active radio communication, integrated engine and steering control, and work-rest management. These findings indicate that

respondents view pre-operational risk control as an important element in strengthening safety behavior while also supporting ship collision prevention in the narrow Barito River channel.



Figure 9. Illustration of the incident chronology [30]

C. Synthesis of Statistical and Operational Findings

The main finding of this study is that JSA implementation and safety behavior are more directly related to ship collision prevention than organizational climate. JSA implementation has the strongest direct effect on safety behavior, while safety behavior has the strongest direct effect on ship collision prevention. This pattern indicates that collision prevention in the Barito River channel is strongly determined by task-level risk-control practices and actual crew behavior during navigation activities. In narrow and dynamic river conditions, crews need clear briefings, route assessment, lookout arrangements, communication procedures, speed control, and maneuvering plans before entering critical areas.

The insignificant effect of organizational climate on safety behavior and its negative direct effect on ship collision prevention should not be interpreted as indicating that organizational climate is unimportant. Rather, the finding suggests that organizational climate may not directly improve collision prevention unless it is operationalized into concrete work practices. Organizational policies, leadership support, communication culture, and learning from incidents need to be translated into JSA implementation, procedural compliance, and bridge-team behavior. This interpretation is consistent with safety behavior literature, which emphasizes that safety climate and organizational conditions influence safety outcomes through safety knowledge, motivation, compliance, and participation.

The real-case assessment strengthens the SEM-PLS results by showing that the statistically significant constructs are also reflected in operational judgment from Port Captains. The respondents consistently

emphasized lookout, communication, role allocation, route and current assessment, speed reduction, and pre-operational risk control. These aspects correspond to the dominant role of JSA implementation and safety behavior in the structural model. Therefore, the combination of SEM-PLS and real-case assessment provides a stronger explanation than statistical survey results alone, because it connects model-based findings with practical decision-making in real tug-and-barge navigation.

The novelty of this study lies in integrating organizational climate, task-based JSA implementation, crew safety behavior, and ship collision prevention into one empirical model for tug-and-barge operations in a narrow inland waterway. Previous studies generally discussed maritime accident causation, safety climate, JSA, safety behavior, or collision risk assessment separately. This study contributes by showing that collision prevention in the Barito River channel is not only a matter of navigation rules or vessel-handling skills, but also a combined result of operational risk control, safe crew behavior, and organizational support. Practically, the findings support the need to strengthen JSA quality, bridge-team communication, role clarity, lookout discipline, and pre-operational briefing as priority actions for improving collision prevention in Barito River navigation.

IV. CONCLUSION

Job Safety Analysis (JSA) implementation and safety behavior are the main factors supporting ship collision prevention in the Barito River channel. JSA was found to have a positive and significant effect on safety behavior and to contribute directly to ship collision prevention,

while safety behavior also showed a positive and significant effect on ship collision prevention. Although organizational climate did not have a significant effect on safety behavior and showed a negative direct effect on ship collision prevention, these findings suggest that its role may be indirect and dependent on the operational context. The SEM-PLS model demonstrated adequate explanatory and predictive power, while the real-case assessment confirmed the importance of lookout, communication, role clarity, and pre-operational risk control in narrow river navigation. Overall, these findings indicate that strengthening JSA practices and safe operational behavior should be prioritized in efforts to improve navigation safety in the Barito River channel.

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AUTHOR CONTRIBUTIONS

S.H.P contributed to conceptualization, methodology, and data survey. S.M contributed to data analysis and manuscript writing. T.C., L.B., M.S., A.P., contributed to supervision, validation, and manuscript review.

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