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Designing Risk Mitigation Strategies Using Enterprise Risk Management (ERM) Based on COSO ERM and House of Risk (HOR) Models

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Abstract

Maritime transportation, as a crucial means of global connectivity, is inherently exposed to various risks. PT. XYZ, a company in this sector, faces significant operational and strategic risks. However, the absence of a dedicated risk management division or a structured mitigation strategy highlights a critical gap in its ability to address these vulnerabilities effectively. This study aims to develop a comprehensive risk mitigation framework that empowers the company to take early preventive actions and strengthen its resilience against potential risks.The research employs the COSO ERM 2017 framework, integrated with the House of Risk (HOR) approach, combining qualitative and quantitative methodologies for comprehensive risk assessment. The findings identify 29 distinct risk events and 42 associated risk agents. By prioritizing these risks using the HOR approach, the study formulates 16 actionable risk mitigation strategies, tailored to address the most pressing threats.The proposed framework emphasizes proactive measures and continuous monitoring to ensure sustainable risk management practices. Recommendations include institutionalizing a dedicated risk management division and embedding the framework into daily operations to foster a risk-aware culture. This study provides a practical and structured approach to risk mitigation, offering valuable insights for PT. XYZ and the broader maritime industry to navigate uncertainties effectively and ensure long-term operational stability.

Keywords: *Enterprise Risk Management (ERM), COSO ERM, House of Risk (HOR), Maritime Tranportation.*

Introduction

Business activities inherently involve potential risks. Therefore, business practitioners must actively seek solutions to manage risks and prevent their occurrence (Pangestuti, 2019). According to ISO 31000:2018, risk is defined as the effect of uncertainty on objectives. These objectives may encompass various aspects, such as financial performance, occupational safety, environmental impact, and can be applied at different organizational levels.

The maritime industry is particularly exposed to risks due to its vulnerability to factors affecting both humans and the environment (Setyohadi et al., 2018; Samekto et al., 2020). Risks faced by the maritime sector include financial risks, reputational damage, safety hazards, and security threats (Chang et al., 2019). According to the International Maritime Safety Agency (IMSA), there were a total of 21,173 ship accidents worldwide from 2014 to 2021.

This study focuses on PT XYZ, established in 2018, which operates in the water transportation sector, primarily as an owner of tugboats and barges. PT XYZ faces several risks, including collisions, engine failures, barge leakage, expired crew certifications, expired vessel documents, and unpredictable weather conditions. Over the past year alone, several risk events have occurred, resulting in significant losses, as detailed in the table below.

Table 1. List of Incident

No	Incident	Date	Possible Causes of Incident	Consequences and Losses	Financial Loss

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1	Broken Barge	06/10/23	• Severe weather • Uneven cargo load (Internal)	• Some cargo falls into the sea • Repairs on the barge • Barge temporary unavailable	± Rp.1.500.000.000
2	Colliding with a House	13/05/24	• Engine Problem • Strong river current (Internal)	• Tugboat repairs • Compensation to local residents	± Rp.750.000.000
3	Colliding with a Dock	27/04/24	• Procedural errors from external parties (Exsternal)	• Barge repairs • Compensation for dock repairs	± Rp.1.500.000.000

Despite there are risks that previously mentioned, PT XYZ currently lacks a dedicated risk management division responsible for identifying, evaluating, and managing potential risks. Additionally, the company has not yet developed effective risk mitigation strategies to prevent similar incidents from recurring in the future.

Enterprise Risk Management (ERM) is a structured and integrated approach to managing risks across an organization (Brown et al., 2019). Within the ERM framework, COSO emphasizes the importance of considering risks as factors that can influence the achievement of organizational objectives, either positively or negatively. Pujawan and Geraldin (2009) developed a supply chain risk management model using the House of Quality (HOQ) and Failure Mode and Effects Analysis (FMEA) concepts, resulting in the framework known as the House of Risk (HOR).

The integration of the COSO ERM framework and the House of Risk (HOR) method is a novel approach introduced in this study, considering the strengths and weaknesses of both methods. The COSO ERM framework highlights the integration of enterprise risk management with strategy and performance, providing a comprehensive framework (Prewett et al., 2018). Meanwhile, the HOR method is utilized to identify and prioritize risk events and agents, as well as to design mitigation strategies (Kusrini et al., 2020).

Based on this context, this research focuses on designing risk mitigation strategies using the Enterprise Risk Management (ERM) approach to identify risks and their causes at PT XYZ, which currently lacks a formal risk mitigation strategy. The methodology employed in this study integrates COSO ERM with the House of Risk (HOR), a combination not previously applied in earlier studies

Literature Review

Risk Management

Risk management is defined as a systematic process for managing risks to achieve organizational objectives while considering public interests, human safety, environmental factors, and legal requirements. This involves planning, organizing, and directing safety operations to develop efficient strategies for reducing the negative impact of risks threatening the organization (Artikis et al., 2015). Another source defines risk management as the process of identifying, assessing, and prioritizing risks, followed by the application of coordinated and cost-effective resources to minimize, monitor, and control the likelihood and/or impact of adverse events (Kubler, 2014; Sharma et al., 2018).

In summary, risk management is the process of managing risks to achieve organizational objectives and mitigate adverse impacts on the organization

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COSO ERM

COSO defines Enterprise Risk Management (ERM) as a series of activities that promote organizational alignment and accountability, emphasizing collective risk identification and responsibility rather than solely focusing on performance improvement or compliance (Tekathen et al., 2013).

In relation to the risk management process, the COSO ERM Integrated Framework addresses enterprise risk management by integrating it with strategy and performance. It highlights the importance of embedding risk management into strategic planning and throughout the organization, as risks influence and align strategy and performance across all departments and functions.

Figure 1. COSO ERM Framework

(Sourcce: www.coso.org)

COSO ERM is often utilized to support the implementation or enhancement of risk management. S. William (2018) discussed the application of ERM to improve risk management in passenger vessels, specifically cruise ships and ferries, using the COSO ERM framework. Additionally, Nugraha et al. and Pratiwi et al. (2023) explored strategies for applying COSO ERM in risk management within manufacturing companies. Based on these studies, it can be concluded that COSO ERM is an appropriate framework for risk management.

House of Risk (HOR)

Pujawan and Geraldin (2009) developed a supply chain risk management model using the House of Quality (HOQ) and Failure Modes and Effects Analysis (FMEA) concepts to create a framework known as the House of Risk (HOR) approach. The HOR approach aims to identify risks and design mitigation strategies to reduce the likelihood of risk agents by implementing preventive actions. Risk agents, or risk causes, are factors that drive the occurrence of risks. Risk events are incidents or occurrences that may negatively impact organizational goals or operations. Therefore, reducing risk agents can subsequently lower the occurrence of multiple risk events.

Identifying priority risks is essential for all organizations to understand potential risks and determine preventive actions. The HOR method has been widely used by various organizations to identify risk causes and develop priority risk mitigation strategies. For instance, Herowati et al. (2018) utilized the HOR method to design risk management strategies for recreational business activities. Similarly, Kusrini et al. (2021) applied this method for risk management in manufacturing companies. Yahya et al. (2021) also used the HOR approach to identify collision causes in ships and propose preventive measures.

Methods

Integration of COSO ERM and House of Risk Methods

This study introduces the integration of the COSO ERM framework and the House of Risk (HOR) method as a novel approach. The integration of these two methods was undertaken by considering the strengths and limitations of each method.

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Table 2. Characteristics of the COSO ERM Method and the House of Risk (HOR) Method

Method	Advantages	Data Processing	Objective
COSO ERM	Identification	Qualitative	Risk reduction and risk avoidance
House of Risk (HOR)	Measurement	Quantitative	Enhancing organizational competitiveness through the identification of priority risk agents and the formulation of risk prevention actions

From the table above, it is evident that each method has distinct characteristics, and this study leverages these differences to achieve an optimal risk mitigation strategy. The integration of these two methods is applied by using the COSO ERM framework as the foundation for risk management. For the measurement process, starting from risk assessment, including risk identification through to risk mitigation, the House of Risk (HOR) method is utilized due to its more quantitative nature. Additionally, one of the advantages of the HOR method is its ability to address a single risk agent with multiple actions, while simultaneously reducing the likelihood of multiple risk agents through a single action.

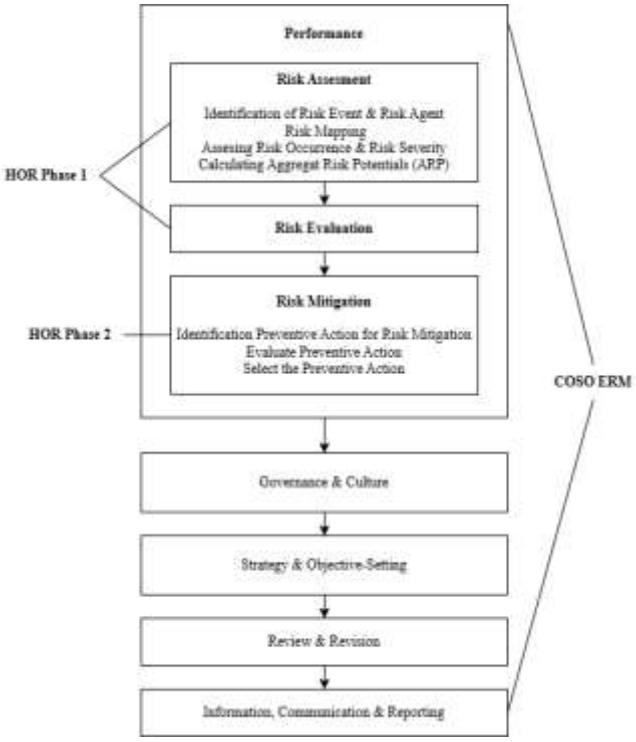

Figure 2. Integration Method of COSO ERM and House of Risk (HOR)

This integration of methods is adapted from the COSO ERM 2017 framework, as shown in Figure 1. However, for the performance aspect, which includes risk management elements such as risk identification, assessing risk severity, and implementing risk mitigation, this study incorporates the additional House of Risk (HOR) method developed by Pujawan and Geraldin in 2009. This integration was carried out to provide clearer results in the design of risk mitigation strategies, with calculations and measurements of risks.

The first step involves performing risk assessment using the HOR method, including risk evaluation and mitigation. Afterward, the process continues with risk monitoring under the COSO ERM framework, which focuses on identifying suitable governance and culture for the company, aligning with risk management, strategy, and the company's objectives. This step includes reviewing and revising the proposed risk mitigation strategies and ensuring proper information dissemination, communication, and reporting within the company.

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House of Risk (HOR) Method

House of Risk (HOR) Phase 1

In stage 1 of the HOR Multi-Actor, it is necessary to integrate the Aggregate Risk Potential (ARP) of the Risk Agents.

The following are the steps and phases for HOR 1:

Identify the potential risk events in each business process. This is done by mapping the business processes and determining what could go wrong or the risks that might occur in each process. In the HOR1 model presented in Table 2.1, the risk events are listed in the left column and denoted as Ei.

Evaluate the impact/severity of each risk event using a scale of {1, 3, 5, 7, 9}, with 9 indicating a very severe or catastrophic impact. The severity of each risk event is placed in the right column of Table 2.1 and denoted as Si.

Identify the risk agents/causes of the risks and the likelihood of each risk agent occurring. The same scale of {1, 3, 5, 7, 9} is applied here, where 1 means it is unlikely to occur and 9 means it is almost certain. The risk agents (Aj) are placed in the top row of the table, and the likelihood of occurrence (Oj) is placed in the bottom row.

Create a relationship matrix that shows the correlation between each risk agent and each risk event, Rij {0, 1, 3, 9}, where 0 indicates no correlation, and 1, 3, and 9 represent low, medium, and high correlations.

Calculate the Aggregate Risk Potential of agent j (ARPj), which is determined as the product of the likelihood of occurrence of risk agent j and the aggregate impact of the risk events caused by risk agent j, as described in equation (1).

$$ARP_j = O_j \Sigma_i S_i R_{ij} \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where:

ARP_j : Aggregrate Risk Potential of Risk Agent-j

O_j : Occurance of Risk Agent-j

S_i : Severity level if Risk Event-i occurs

R_{ij} : Relationship between Risk Event-i and Risk Agent-j (Correlation Value)

Rank the risk agents based on their aggregate risk potential, from the highest to the lowest.

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Table 3. House of Risk (HOR) phase 1

Business processes	Risk event (E_i)	Risk agents (A_j) A_1	A_2	A_3	A_4	A_5	A_6	A_7	Severity of risk event i (S_i)
Plan	E_1	R_{11}	R_{12}	R_{13}					S_1
	E_2	R_{21}	R_{22}						S_2
Source	E_3	R_{31}							S_3
	E_4	R_{41}							S_4
Make	E_5								S_5
	E_6								S_6
Deliver	E_7								S_7
	E_8								S_8
Return	E_9								S_9
Occurrence of agent j		O_1	O_2	O_3	O_4	O_5	O_6	O_7	
Aggregate risk potential j		ARP_1	ARP_2	ARP_3	ARP_4	ARP_5	ARP_6	ARP_7	
Priority rank of agent j									

(Source: Pujawan & Geraldin, 2009)

House of Risk (HOR) Fase 2

After selecting and identifying high-value risk agents in Phase 1, Phase 2 is used to prioritize the preventive actions that should be implemented first. This prioritization is based on the effectiveness of the actions, the resources involved, and the level of difficulty in their execution.

The following are the steps and stages for HOR2 :

Select a number of high-priority risk agents from the ARPj to be addressed in HOR2. The selected risk agents will be placed on the left side of HOR2, as shown in Table 2.2. The corresponding ARPj values should be placed in the right column.

Identify relevant actions that are considered effective for mitigating the risk agents. It should be noted that one risk agent may be addressed by more than one action, and a single action may simultaneously reduce the likelihood of multiple risk agents. These actions are placed in the top row of HOR2.

Determine the relationship between each preventive action and each risk agent (Ejk). The values can be {0, 1, 3, 9}, where each value represents no, low, medium, and high correlation between action k and risk agent j. This relationship (Ejk) can be considered as the effectiveness level of action k in reducing the likelihood of risk agent j occurring.

Calculate the total effectiveness of each action as follows:

$$TE_k = \Sigma_j ARP_j E_{jk} \text{.....(2)}$$

Where :

A_j : Selected risk agent-j to be addressed

PA_k : Preventive action-k to be implemented

E_{jk} : Correlation between preventive action-k and risk agent-j

ARP_j : Aggregate Risk Potential-j

TE_k : Total effectiveness of each preventive action

Evaluate the difficulty level in implementing each action (Dk) and place the values below the total effectiveness. The difficulty level, which can be represented by the scale {1, 3, 5, 7, 9}, should reflect the

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funds and other resources needed to implement the action.

Calculate the ratio of total effectiveness to difficulty as follows:

$$ETD_k = \frac{TE_k}{D_k} \text{.....(3)}$$

Where :

ETD_k: Ratio of total effectiveness to the difficulty level of preventive action-k

TE_k : Total effectiveness of each preventive action

D_k : Difficulty level in implementing preventive action-k

Determine the priority ranking for each action (Rk), where Rank 1 is assigned to the action with the highest $ETDk$

Table 4. House of Risk (HOR) phase 2

To be treated risk agent (A_i)	Preventive action (PA_k)					Aggregate risk potentials (ARP_i)
	PA_1	PA_2	PA_3	PA_4	PA_5	
A_1	E_{11}					ARP1
A_2						ARP2
A_3						ARP3
A_4						ARP4
Total effectiveness of action k	TE_1	TE_2	TE_3	TE_4	TE_5	
Degree of difficulty performing action k	D_1	D_2	D_3	D_4	D_5	
Effectiveness to difficulty ratio	ETD_1	ETD_2	ETD_3	ETD_4	ETD_5	
Rank of priority	R_1	R_2	R_3	R_4	R_5	

(Source: Pujawan & Geraldin, 2009)

Business Process

To design an effective risk management framework, the first step is to determine and understand the scope of the risks. By establishing boundaries and identifying this scope, the company can recognize the most significant and relevant risks to its operations and objectives. This process helps ensure that risk mitigation efforts are focused on areas with the greatest impact on the company, allowing resources to be allocated more efficiently and risk management strategies to be more effective. The first step in understanding the scope of risks within a company is to map the company's business processes.

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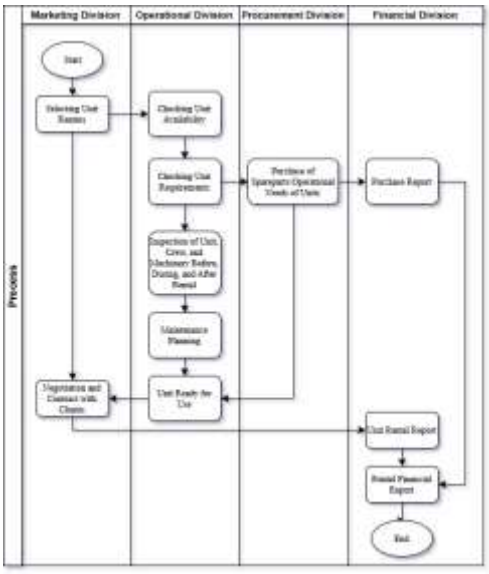

Figure 3. Business Process

Result

Performance

- Risk Assesment (House of Risk Phase 1)

Identification Stage

In the identification phase, two key elements need to be identified: risk events and risk agents. A risk event is an incident or occurrence that can negatively impact the organization's objectives or operations.

Table 5. Risk Event

Sub-Processes	Code (Ei)	Risk Event	Information
Selecting Unit Renters	E1	Clients do not renew contracts	(Saifudin et al, 2022)
	E2	Competitors offering lower prices	(Chapman, 2006)
	E3	New transportation alternatives more appealing to the market	(Chapman, 2006)
Checking Unit Availability	E4	Barge structural failure	Interview
	E5	Barge leakage	Interview
Inspecting Units, Crew, and Machinery Before, During, and After Rental	E6	Vessel colliding with public property	Interview
	E7	Vessel colliding with docks	Interview
	E8	Explosion/fire onboard the vessel	(Cho et al, 2018)
	E9	Vessel unable to dock at the port	Interview
	E10	Cargo falling into the sea	Interview
	E11	Collision between vessels	(Yahya et al, 2021)
	E12	Vessel hijacking	Interview
	E13	Accidents involving crew members	(Adiningrat et al, 2024)
	E14	Reputational risk due to pollution incidents	(Grant et al, 2018)

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	E15	Environmental damage, such as oil spills into the sea	(Bi et al, 2012)
	E16	Limited availability of competent crew	(Adiningrat et al, 2024)
	E17	Expired vessel documentation	Interview
	E18	Expired crew certifications	Interview
	E19	Engine breakdown or failure	Interview
	E20	Damaged vessel navigation systems	(Cho et al, 2018)
Maintenance Planning	E21	Delayed vessel maintenance schedules	(Jiang et al, 2017)
Purchasing Spare Parts/Operational Needs for Units	E22	Theft of vessel spare parts/equipment	(Jiang et al, 2017)
Preparing Financial Reports for Rentals	E23	Insurance claims being denied	(Saifudin et al, 2022)
	E24	Corruption	(Handoko et al, 2020)
	E25	Challenges in securing bank loans	(Liu, 2020)
	E26	Rising operational costs	(Liu, 2020)
	E27	Delayed payments to business partners	(Saifudin et al, 2022)
	E28	Financial difficulties	(Liu, 2020)
-	E29	Reports of corporate misconduct to authorities	Interview

A risk agent is a source or potential cause of a risk event, meaning it is the factor that triggers a risk occurrence. From the risks identified earlier, whether through interviews or literature review, this phase aims to identify the causes that lead to these risks. A single risk event can be caused by multiple risk agents.

Table 6. Risk Agent

Risk Event	Code (Aj)	Risk Agent
E1	A1	Unit does not meet expectations
E1	A2	Slow problem resolution
E2	A3	Lack of operational efficiency within the company
E3	A4	Absence of technological innovation within the company
E4	A5	Overloaded cargo
E5	A6	Insufficient vessel maintenance
E6	A7	Navigation system failure
E6	A8	Low visibility
E7	A9	Strong river currents
E8	A10	Crew inattentiveness due to fatigue
E8	A11	Mishandling of flammable materials onboard
E8	A12	Fuel leakage
E8	A13	Overheating of mechanical equipment
E9	A14	Inadequate water depth
E10	A15	Insecure cargo storage system for various conditions
E11	A16	Extreme weather and high waves
E11	A17	Poor communication and coordination
E12	A18	Insufficient maritime traffic security
E13	A19	Non-compliance with onboard safety procedures (SOP) by crew members

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E13	A20	Ineffective implementation of safety, health, and environment (HSE) procedures
E14	A21	Improper waste management
E14	A22	Neglect of environmental issues in the maritime sector
E15	A23	Non-compliance with regulations established by governing authorities
E16	A24	Workforce competition with other companies
E16	A25	Limited training programs
E16	A26	Aging crew members
E17, E18	A27	Ineffective document management
E17, E18	A28	Lack of an accurate and up-to-date inventory tracking system
E19	A29	Insufficient crew training on vessel systems
E19	A30	Fuel not meeting specifications or being contaminated
E20	A31	Non-compliance with safety procedures
E20	A32	Electronic interference
E21	A33	Overcrowded docking areas
E22	A34	Limited security and surveillance
E23	A35	Incomplete documentation or non-compliance with policy terms
E24	A36	Weak regulations to prevent and address corruption
E25	A37	Low company credit rating at banks
E26	A38	Inefficient financial management
E27	A39	Ineffective payment methods or regulations in use
E28	A40	Lack of clear agreements between investors and the company
E28	A41	Failure to adhere to existing financial procedures
E29	A42	Insufficient communication between the company and reporters or stakeholders

Risk Analysis Stage

The risk analysis phase is conducted to assess risk occurrence and risk severity. Risk severity refers to the evaluation of the potential impact or loss that would result if a risk event were to occur.

Table 7. Risk Severity

Code (Ei)	Risk Event	Severity
E23	Insurance claims are not eligible	7
E24	Corruption	7
E25	Difficulty for the company to obtain bank credit	5
E26	Increased operational costs	7
E27	Delayed payments to business partners	7
E28	Financial difficulties	7
E4	Barge structural failure	9
E5	Barge leakage	7
E6	Vessel collides with public property	9
E7	Vessel collides with the dock	9
E8	Explosion/fire onboard the vessel	9
E9	Vessel unable to berth at the port	5

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E10	Cargo falls into the sea	7
E11	Vessel collision with another vessel	9
E12	Vessel hijacking	9
E13	Crew member injuries	7
E16	Limited availability of competent crew members	5
E17	Expired vessel documentation	7
E18	Crew certifications expired	7
E19	Vessel engine failure	9
E20	Navigation system malfunction	7
E21	Delayed vessel maintenance schedule	5
E22	Theft of vessel spare parts or equipment	7
E14	Reputational risk due to pollution incidents	7
E15	Environmental damage, such as oil spills into the sea	9
E1	Clients do not renew contracts	7
E2	Competitors offering lower prices	1
E3	New, more attractive transportation options enter the market	7
E29	Reporting of the company to authorities	7

Risk occurrence refers to the assessment of how frequently a risk agent can cause a risk event to occur.

Table 8. Risk Occurrence

Code (Aj)	Risk Agent	Occurrence
A1	Units not meeting expectations	3
A2	Delayed problem resolution	3
A3	Lack of operational efficiency within the company	5
A4	Absence of technological innovation by the company	7
A5	Overloaded cargo	5
A6	Insufficient vessel maintenance	7
A7	Navigation system failure	5
A8	Reduced visibility	7
A9	Strong river currents	7
A10	Crew inattention due to fatigue	3
A11	Improper handling of flammable materials onboard	3
A12	Fuel leakage	5
A13	Overheating of mechanical equipment	5
A14	Inadequate water depth	3
A15	Cargo storage systems not secure under all conditions	7
A16	Extreme weather and high waves	9
A17	Poor communication and coordination	7
A18	Minimal maritime traffic security measures	9
A19	Crew members not adhering to onboard safety (K3) procedures	5
A20	Non-implementation of safety (K3) procedures	7
A21	Improper waste management	7
A22	Neglect of maritime environmental issues	3

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A23	Non-compliance with regulations set by governing bodies	1
A24	Workforce competition with other companies	1
A25	Limited training programs	3
A26	Aging crew members	1
A27	Ineffective document management	7
A28	Lack of a proper and up-to-date inventory tracking system	7
A29	Insufficient training for crew members on vessel systems	3
A30	Fuel not meeting specifications or being contaminated	3
A31	Non-compliance with safety procedures	3
A32	Electronic interference	3
A33	Docking area congestion	7
A34	Limited security and monitoring measures	7
A35	Incomplete or non-compliant documentation with policy requirements	5
A36	Weak regulations to prevent and address corruption	5
A37	Low company credit rating with banks	3
A38	Inefficient financial management	5
A39	Ineffective payment methods or regulations	5
A40	Absence of clear agreements between investors and the company	7
A41	Non-adherence to financial procedures	5
A42	Poor communication between the company and reporting parties	5

Risk Evaluation Stage

After obtaining the values for risk severity and risk occurrence, a correlation value is needed to determine the aggregate risk potential (ARP). This correlation value is derived from a matrix that maps the relationship between risk events and risk agents. In this study, three respondents were involved in determining the correlation values.

Table 9. HOR Phase 1 of Respondent 1

		Risk Agent (Aj)																																										Severity
		A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	A24	A25	A26	A27	A28	A29	A30	A31	A32	A33	A34	A35	A36	A37	A38	A39	A40	A41	A42	
Risk Event (Ei)	E1	9	3																																									7
	E2			3																																								1
	E3				3																																							7
	E4					9	9																																					9
	E5						9																																					7
	E6							9	9	9	9																			3														9
	E7							9	9	9	9							3												3														9
	E8										3	9	9	3																														9
	E9							3	9						9			3												3														5
	E10					9				9						9	9																												7
	E11								9	9	9							9	9											3		3												9
	E12																			9				3																				9
	E13									3								3			9	9		3								9												7
	E14												3										9	9	9																				7
	E15												3											9	9																				9
	E16																									9	9	9																		5
	E17																												9																7
	E18																												9																7
	E19						9			3			3	3																3	9													9
	E20						9							3																			9											7
	E21																																		9										5
	E22																												9							9									7
	E23																																				3								7
	E24																												3							9		9						7
	E25																																						9						5
	E26		9	9																											3								9					7
	E27																																								9				7
	E28			3																																				9		9	3		7
	E29																																											9	7
Occurrence		3	3	5	7	5	7	5	7	7	3	3	5	5	3	7	9	7	9	5	7	7	3	1	1	3	1	7	7	3	3	3	3	7	7	5	5	3	5	5	7	5	5	
ARP		189	252	435	147	720	2016	885	2016	2478	810	243	780	375	135	441	1485	861	729	315	441	441	432	192	45	135	45	882	588	369	306	270	189	315	882	105	315	135	630	315	441	105	315	

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Table 10. HOR Phase 1 of Respondent 2

		Risk Agent (Aj)																																								Severity
		A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	A24	A25	A26	A27	A28	A29	A30	A31	A32	A33	A34	A35	A36	A37	A38	A39	A40	A41	A42	
Risk Event (Ei)	E1	9	9																											3														7
	E2			9	3																																		3					1
	E3				9																																							7
	E4					9	3										9																											9
	E5						9																																					7
	E6							9	9	9	9																																	9
	E7							9			9							9																										9
	E8											9	9	9																	3	9												9
	E9														9																													5
	E10					1										9	9																											7
	E11							9	9		3							9																											9
	E12																		9																										9
	E13																9			9	9													9										7
	E14																					9	9	9																				7
	E15												9				9					9	3	9																					9
	E16																								3	9	1																	5
	E17																											9																7
	E18						9																					9																7
	E19						9																							9	9													9
	E20													3																			9											7
	E21																																	9										5
	E22																												9						9									7
	E23																																			9								7
	E24																																				9		9		3			7
	E25																																					9						5
	E26																																						9					7
	E27																																							9				7
	E28																																								9	9		7
	E29		3																				9																				9	7
Occurrence		3	3	5	7	5	7	5	7	7	3	3	5	5	3	7	9	7	9	5	7	7	3	1	1	3	1	7	7	3	3	3	3	7	7	5	5	3	5	5	7	5	5	
ARP		189	252	45	462	440	1638	1215	1134	567	567	243	810	510	135	441	2592	1134	729	315	441	1449	270	144	15	135	5	882	441	306	324	432	189	315	882	315	315	135	510	315	441	315	315	

Table 11. HOR Phase 1 of Respondent 3

		Risk Agent (Aj)																																								Severity
		A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	A24	A25	A26	A27	A28	A29	A30	A31	A32	A33	A34	A35	A36	A37	A38	A39	A40	A41	A42	
Risk Event (Ei)	E1	3	3	3	9	3	3	1			3	1			0	9	3	1	1	9	9	3	3	3	1	3		3	3	1	1	9	1	1	1	9	9	1	9	3	9	9	9	7
	E2				1		1								0	9									3															3			1	0	1
	E3	1	1	3	9		3								0	1									3		1	3	1	1	3	1												7
	E4					3	9			1	1				1	3	3							1						1		1			1									9
	E5		1			3	9			1	1			1	1	3	3							1						1		1			1									7
	E6					3	1	3	9	1	3						3	1														1	1		1									9
	E7					3		3	9	1	3						3	1														1	1		1									9
	E8					1	3			1	1	9	3	3		1		1		1	1			1						1	1	3			1									9
	E9		3			1	1	3	9	3	1	1			1		3	1						1						1		1	1	9									5
	E10			1		9				3	3	1				9	1																		1									7
	E11					1	1	9	9	1	9						1	1						1						1		3	1		1									9
	E12							1	3		9							1	9	9										1			3		3	1							1	9
	E13			1		9	3	3	3	3	9	9	1	3	1	1	3	1			9			1		3				1	1	9			3	1							1	7
	E14	1		1								3	9	1								9	9	1																			7
	E15				1	3					3	3	9	1						1		9	9	1					1	1				1									9
	E16	3	3	3														3						3	1	9	1							1		1							1	5
	E17	3																3										9													1	1	7
	E18	3								1	3	9		9				3									3	3							1							1	1	7
	E19	1	3		1	9			1	3	9		9		1														1	9	1	1		3		1						9
	E20	1	1			3	9			3	3		3																1		1	3										7
	E21	9	1			3	3	1										9	9										1				1	3							1	1	3	5
	E22									9																			1						3								7
	E23																	9										1					1			1	1	1	1	1	1		7
	E24		3															9											3						9		3					3	7
	E25	1																9						1				1						9	9	3	1		1			5
	E26		1	9		3					1	9	3	3			1	1				1							1	3		3	1	1		1	0	3	1	1	3	1	7
	E27		1	1														9										1										3	9	1	1		7
	E28		1	3		0						1						1																				3	3	9	1	3	9		7
	E29		1	1		3	3	3	1		9	9	9	9		3		1	1	9	9	9	9	3				1		1	1	3			1	9	9	1		3			1	7
Occurrence		3	3	5	7	5	7	5	7	7	3	3	5	5	3	7	9	7	9	5	7	7	3	1	1	3	1	7	7	3	3	3	3	7	7	5	5	3	5	5	7	5	5	
ARP		99	672	1040	1043	1665	2954	1430	2436	826	1677	1338	1310	1285	84	1589	1719	2884	1260	1125	1386	1645	684	124	36	261	33	1064	427	309	501	789	402	567	4662	735	1145	240	1070	725	770	1035	635	

After obtaining the ARP values from each respondent, these values are averaged and ranked from highest to lowest, presented in a Pareto diagram. Subsequently, priority risk agents are selected those that contribute to 80% of the impact. In this study, 22 risk agents were identified as priority.

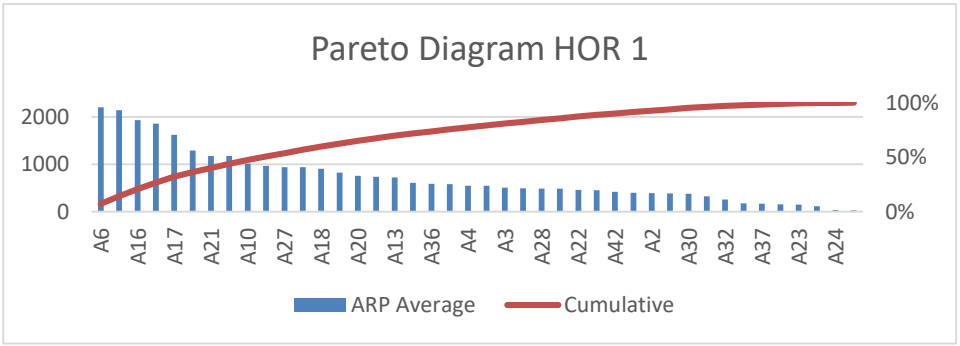

Figure 4. Pareto Diagram HOR Phase 1

- Risk Mitigation (House of Risk Phase 2)

Risk Mitigation Identification Stage

Based on the prioritized risk agents or causes identified earlier risk mitigation strategies or preventive actions are provided in the tabel below.

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Table 12. Risk Mitigation

Risk Agent	Code (PAk)	Risk Mitigation
A6, A12	PA1	Schedule regular maintenance activities.
A6	PA2	Utilize condition monitoring systems for real-time vessel condition tracking.
A6	PA3	Allocate a dedicated budget, including contingency funds, for unit maintenance.
A34	PA4	Conduct unannounced inspections.
A34	PA5	Perform periodic audits.
A34	PA6	Enforce regulations with deterrent effects, such as termination or monetary fines.
A16	PA7	Invest in weather and sea condition monitoring systems to obtain accurate and up-to-date information.
A16, A8	PA8	Prepare alternative routes for each operational schedule.
A16	PA9	Identify emergency ports for shelter.
A16, A9	PA10	Insure both vessels and cargo.
A16, A8, A11	PA11	Provide regular training for staff, crew, and vessel operators.
A16, A9	PA12	Equip vessels with adequate safety equipment.
A17	PA13	Use integrated and user-friendly communication technology for real-time information exchange.
A17	PA14	Implement a management information system that allows easy and real-time access to critical data for all stakeholders.
A21	PA15	Comply with international maritime regulations, such as MARPOL, for waste management activities.
A21	PA16	Monitor and control waste management to ensure no illegal discharge into the sea.
A7	PA17	Foster a safety-oriented culture across the organization.
A7	PA18	Use AIS (Automatic Identification System) to track vessel locations in real-time and prevent collisions.
A7	PA19	Provide detailed and easily accessible manuals for navigation equipment.
A7	PA20	Prepare backup systems and portable equipment for emergency situations.
A7	PA21	Develop and adhere to SOPs that outline steps for both emergency and routine operations.
A10	PA22	Create work schedules with limits on working hours and shift rotations.
A27	PA23	Implement an electronic document management system to digitally store, manage, and track all documents.
A27	PA24	Set reminders for periodic renewal of necessary documents.
A5	PA25	Establish contract terms specifying cargo limits for safety reasons.
A18	PA26	Map red zones or piracy-prone areas during scheduling.
A18	PA27	Coordinate with relevant authorities.

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A18	PA28	Develop security protocols for entering red zones, such as installing barbed wire along the unit and securing cargo.
A15	PA29	Implement cargo management strategies to ensure balanced loads and secure cargo using ropes, chains, or other restraints to prevent shifting.
A20, A19	PA30	Disseminate SOPs for onboard work activities and mandatory procedures.
A3, A38	PA31	Implement an ERP (Enterprise Resource Planning) system.
A38	PA32	Hire consultants for preparing financial reports.
A4	PA33	Invest in research and development activities, including collaborating with third parties for maritime technology innovations or attending forums and conferences to stay updated and relevant.
A36	PA34	Ensure transparent and structured financial reporting.
A4	PA35	Benchmark with other maritime companies.

Calculating Risk Mitigation Stage

After identifying the preventive actions for risk mitigation, the correlation values are required once again. At this stage, the correlation values from the matrix between risk agents and risk mitigation actions are needed to determine the Total Effectiveness of each action (TEk). Additionally, the priority of mitigation actions must be assessed, considering the implementation difficulties (Dk), in order to determine the ratio of Effectiveness to Difficulties (ETDk). Figure below are the results from the three respondents.

Table 13. HOR Phase 2 of Respondent 1

		Preventive Action (Pak)																																			ARP
		PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8	PA9	PA10	PA11	PA12	PA13	PA14	PA15	PA16	PA17	PA18	PA19	PA20	PA21	PA22	PA23	PA24	PA25	PA26	PA27	PA28	PA29	PA30	PA31	PA32	PA33	PA34	PA35	
Risk Agent (Aj)	A6	9	9	9																																	2203
	A34				9	9	9																															2142
	A16							9	9	9	9	9	9																									1932
	A8								9			9																										1862
	A17													9	9																							1626
	A9										9		9																									1290
	A21															9	9																					1178
	A7																	9	9	9	9	9																1177
	A10																						9															1018
	A12	3																																				967
	A27																							9	9													943
	A5																									9												942
	A18																										9	9	9									906
	A15																													9								824
	A11											9																										756
	A20																														9							756
	A3																															9						743
	A38																															9	9					737
	A13	9																																				734
	A36																																			9		731
	A19																														9							585
	A4																																			9	9	551
TEk		29330	19824	19824	19278	19278	19278	17388	34146	17388	29001	40950	29001	14637	14637	10605	10605	10590	10590	10590	10590	10590	9162	8484	8484	8475	8154	8154	8154	7413	12069	13317	6630	4956	6579	4956	
Dk		1	7	5	1	3	5	7	3	1	3	5	3	3	5	3	3	3	3	3	3	1	1	3	3	1	1	3	7	5	3	7	5	7	3	7	
ETD		29330	2832	3965	19278	6426	3856	2484	11382	17388	9667	8190	9667	4879	2927	3535	3535	3530	3530	3530	3530	10590	9162	2828	2828	8475	8154	2718	1165	1483	4023	1902	1326	708	2193	708	

Table 14. HOR Phase 2 of Respondent 2

		Preventive Action (Pak)																																			ARP
		PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8	PA9	PA10	PA11	PA12	PA13	PA14	PA15	PA16	PA17	PA18	PA19	PA20	PA21	PA22	PA23	PA24	PA25	PA26	PA27	PA28	PA29	PA30	PA31	PA32	PA33	PA34	PA35	
Risk Agent (Aj)	A6	9	9	9																																	2203
	A34				9	9	9																															2142
	A16							9	9	9	9	3	9									1																1932
	A8								9			9										1																1862
	A17													3	9				3																			1626
	A9										9		9									1																1290
	A21											3				3	9																					1178
	A7											1	3	9	9			9	9	9	3	3																1177
	A10																						9															1018
	A12	3																				3									1							967
	A27																							9	9							3						943
	A5																									9												942
	A18											9	3									9					9	9	9									906
	A15																													9								824
	A11											1										3										1						756
	A20																	9													9							756
	A3																															9						743
	A38																															3	9					737
	A13	9																				1																734
	A36																																			9		731
	A19																	9														9						585
	A4																															3		9		9	551
TEk		29330	19824	19824	19278	19278	19278	17388	34146	17388	29001	36176	35249	15469	25227	3535	10605	22659	15469	10590	3530	22670	9162	8484	8484	8475	8154	8154	8154	7413	13792	13377	6630	4956	6579	4956	
Dk		1	7	5	1	1	3	7	1	1	3	7	5	3	3	3	3	3	3	5	1	1	1	5	1	1	1	3	5	3	3	7	3	7	5	7	
ETD		29330	2832	3965	19278	19278	6426	2484	34146	17388	9667	5168	7050	5156	8409	1178	3535	7553	5156	2118	3530	22670	9162	1697	8484	8475	8154	2718	1631	2471	4597	1911	2210	708	1316	708	

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Table 15. HOR Phase 2 of Respondent 3

		Preventive Action (Pak)																																		ARP
		PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8	PA9	PA10	PA11	PA12	PA13	PA14	PA15	PA16	PA17	PA18	PA19	PA20	PA21	PA22	PA23	PA24	PA25	PA26	PA27	PA28	PA29	PA30	PA31	PA32	PA33	PA34	PA35	
Risk Agent (Aj)	A6	9	9	9																																	2203
	A34				9		3																														2142
	A16							9	3	9	9	9	9								3	1						3									1932
	A8							9	3	3		9									3	1															1862
	A17													9	9				3																		1626
	A9							9	3		9		9								3	1															1290
	A21											3				9	9																				1178
	A7		3									1	3	9	9			9	9	9	9	9															1177
	A10		1																				9														1018
	A12	3	3																		1	3						3			1						967
	A27																							9	9							3					943
	A5																									9											942
	A18								9	9	9	9	3									9					9	9	9								906
	A15																													9							824
	A11											1									1	3									1						756
	A20																	9													9						756
	A3					9																	1									9				3	743
	A38					9																										9	9			3	737
	A13	3																				1															734
	A36				3	3	9																													9	731
	A19				3													9													9					585
	A4																															3				9	551
TEk		24926	27272	19824	23226	15510	13005	45759	23407	31128	37155	47768	35249	25227	25227	10605	10605	22659	15469	10590	27566	29730	9905	8484	8484	8475	8154	16850	8154	7413	13792	17797	6630	4956	11018	4956	
Dk		1	5	5	1	3	3	5	3	1	3	3	3	1	3	3	5	3	5	5	3	1	3	5	3	1	3	3	3	3	1	7	3	5	3	7	
ETD		24926	5454	3965	23226	5170	4335	9152	7802	31128	12385	15923	11750	25227	8409	3535	2121	7553	3094	2118	9189	29730	3302	1697	2828	8475	2718	5617	2718	2471	13792	2542	2210	991.2	3673	708	

Evaluate dan Select Risk Mitigation Stage

After obtaining the ETD values from each respondent, these values are averaged and ranked from highest to lowest, presented in a Pareto diagram. Subsequently, priority risk mitigations are selected those that contribute to 80% of the impact. In this study, 16 risk mitigations were chosen.

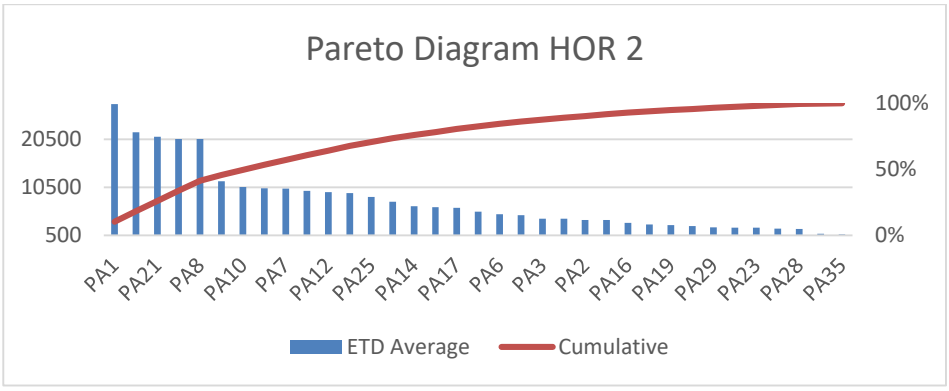

Figure 5. Pareto Diagram HOR Phase 2

Governance & Culture

The implications of corporate governance for the current risk management context at PT XYZ have yet to materialize. PT XYZ currently lacks both a strategy and a dedicated division to analyze and address risk management within the company. Risks occurring within the organization are addressed reactively, only after the risks have manifested, without tackling the root causes or mitigating them at their origins. Risk management at PT XYZ thus far has been conducted solely based on the company's financial conditions. According to the COSO ERM 2017 framework, several key points within governance and culture can support the implementation of effective risk management practices.

Table 16. Initiatives for Governance & Culture on PT XYZ

COSO ERM	Implication on PT XYZ
Conducting Risk Oversight by the Board of Directors	• The board of directors adheres to compliance and ethics (C&E) regulations specific to the maritime environment. • The board of directors conducts regular oversight of C&E programs. • The board of directors establishes roles to support the supervision of C&E initiatives. • The board of directors ensures adequate resources are allocated to

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	C&E programs. • The board of directors receives periodic reports on the implementation and progress of C&E programs.
Establishing an Operational Structure	• PT XYZ establishes an organizational structure that supports the implementation of risk management. • Positions related to risk management are given higher authority compared to other functional leaders. • The role can be assigned to an existing employee within the company or a newly recruited, experienced individual specifically for risk management purposes. • If a dedicated risk management division is created, staff from other functional divisions may be included.
Defining the Desired Organizational Culture	• In addition to the corporate culture established from the outset, implement a culture of compliance and integrity. • Establish a culture of risk awareness. • Foster this culture across all levels, from staff to the board of directors, ensuring continuous vigilance and concern for potential risks.
Demonstrating Commitment to Core Values	• Actively promote a culture of risk awareness and compliance, including establishing ethical conduct and compliance in leadership. • Implement a commitment to compliance starting from the highest levels of the company. • Compliance risks and their implementation should be incorporated into performance evaluations, promotions, and incentives to ensure sincere adherence.
Attracting, Developing, and Retaining Qualified Individuals	• Maintain the performance of staff with expertise in risk management. • If there are no competent staff in risk management, recruit new personnel specifically for this role. • Provide regular training on risk management to ensure that PT XYZ consistently has competent resources in risk management.

Strategy & Objective-Setting

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Based on the COSO ERM 2017 framework, risk management must be integrated into the company's strategy and goal-setting processes. Currently, PT XYZ's strategy and goals are still defined in general terms. At this stage, strategy and goal-setting need to be aligned with risk management, and there are several key points in this phase.

- *Business Context Analysis*

PT XYZ, which has been operating for 6 years, has likely analyzed the business context and how its operations are conducted. In terms of risk management, analyzing the business context helps in understanding the potential risks that could affect the business, specifically in the maritime sector. Currently, PT XYZ is aware of its business context and the common issues faced in the maritime industry. However, as previously mentioned, PT XYZ only addresses risks after they have occurred, with no further action taken. Therefore, this study proposes a new organizational or governance structure that incorporates risk management implications, aimed at implementing risk mitigation strategies and ensuring the sustainability of risk identification and mitigation efforts outlined in the performance phase.

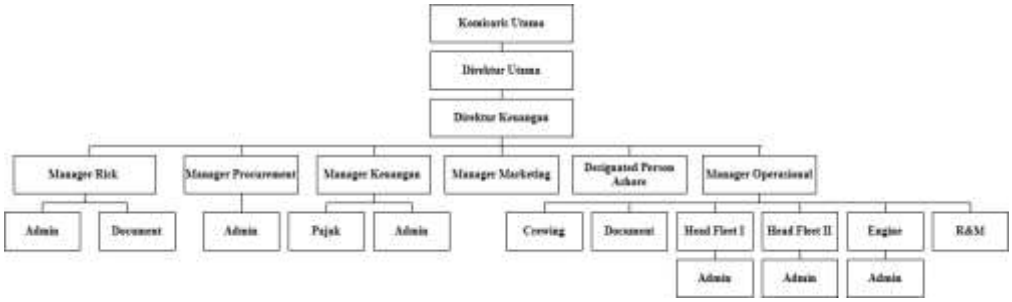

Figure 6. Organization Structure Suggestions

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The clear difference is the establishment of a new division, namely the risk division. With the business context analysis previously conducted by PT XYZ, the risk division's assistance can help the company analyze potential risks in the maritime sector and ensure the continuity of the proposed risk mitigation strategies outlined in this study. Without a dedicated risk division or personnel, PT XYZ would face challenges in evaluating or regularly updating future risks. Furthermore, the main risks faced by PT XYZ are predominantly classified as high and medium risks, rather than low risks.

- *Define Risk Appetite*

As defined by COSO, risk appetite refers to the type and amount of risk, at a broad level, that an organization is willing to accept in pursuit of value. Risk appetite varies across organizations depending on their ability and reliability in managing risks. In PT XYZ, since there is currently no division or personnel with risk management expertise, the risk appetite is entirely determined by the director. After the proposed governance structure is implemented, the risk division will define the risk

- *Evaluate Alternative Strategies*

Effective risk management can only be achieved if the compliance function is implemented across all levels of the organization. Additionally, before implementing risk management, a thorough identification and analysis of potential risks within the organization must be conducted. However, for risk management to remain effective, periodic updates are required in alignment with changes in strategy, risk appetite, and the identification of new risks that were previously unrecognized. This is referred to as alternative strategies in the context of risk management according to the COSO ERM framework, and it must be evaluated regularly.

- *Formulate Business Objectives*

The company needs to set objectives that align with the risk tolerance established by the risk division and the board of directors. This ensures that the objectives are realistic and achievable without taking on uncontrolled risks.

Review & Revision

After identifying risks and their mitigations, it is necessary to monitor the identified risks to ensure they remain mitigated. Therefore, Key Performance Indicators (KPIs) for risk management are needed at PT XYZ. KPIs are created to ensure that the identified risks and their mitigations remain relevant or if any changes occur. If changes are identified, revisions will be required to align risk management with the company's strategy to achieve its objectives. This process will continue to be implemented to improve the ERM framework at PT XYZ.

Table 17. Review & Revision Strategies on PT XYZ

KPI Components	Information	Measurement Criteria
Monitoring and assessment of risks and their mitigations	• Assessment of risks and their mitigations • Monitoring of initially proposed risks and their mitigations to determine their continued relevance • PT XYZ needs to understand the risk appetite for each identified risk.	• Risk assessment should be conducted every 6 months. If the risk exceeds the defined risk appetite, a risk mitigation strategy should be implemented. • Relevance assessment of risks should be conducted every 3 months. If the proposed risks are no longer relevant, they should be moved to the risk and mitigation update identification phase.

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Risk management and its mitigations	• Management of potential risks if new risks are identified • Risk management is also carried out periodically by the risk division • Risk mitigation is implemented if the risk falls outside the risk appetite defined by the board of directors and the risk division	• If a new risk is identified at any time, the risk appetite for that risk must be determined. • A risk mitigation strategy should be implemented if the new risk assessment falls outside the defined risk appetite. • Once the new risk is identified and has a corresponding mitigation strategy, it should be moved back to the risk monitoring and assessment phase.
Identification of risk updates and their mitigations	• If it is determined that the previous risks and mitigations are no longer relevant, a reassessment of the risks and their mitigations should be conducted.	• The identification of risk updates and their mitigation should be conducted annually. • The identification of risk updates and their mitigation should also be carried out whenever there are significant changes within the company.

Information, Communication & Reporting

Corporate risk management requires a continuous process of acquiring and sharing necessary information. This is a key element that ensures the risk management process operates effectively and transparently throughout the organization. This stage also includes the monitoring and controlling of risks.

Table 18. Information, Communication & Reporting Elements

Elements	Description
Information	The collection, processing, and storage of information using technology (such as dashboards) are necessary to facilitate decision-making related to risk management.
	Information on the dashboard is accessible to all elements of PT XYZ, from directors to staff, to ease the decision-making process.
	The information on the dashboard is updated annually, following the identification of updated risks and mitigation actions conducted by the risk division.
	In addition to annual updates, the information is updated whenever there is a significant change in the company or when new risks are identified outside of the regular risk and mitigation updates.
	All information and changes regarding risks can only be made by the risk division, subject to the approval of the board of directors.
Communication	Communication channels are facilitated to distribute information, such as regular meetings and management information systems.
	Regular meetings regarding risks are held every 6 months, coinciding with the monitoring and assessment of risks and their mitigations. Additionally, communication regarding risks can be made to the risk division at any time if another division identifies a critical risk that will be addressed by the risk division.
	Relevant risk information is communicated to external parties, such as regulators, investors, and clients, on an annual basis.
Reporting	Periodic reports on potential risks, risk management performance, and the status of established risk mitigation in the KPI are compiled.

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	The periodic risk assessment reports will be conducted every 6 months, while the updates on risks and mitigations will be carried out annually. These reports will be discussed from the risk division to the board of directors and then communicated to each division.
	Annual reports are prepared, including relevant risk information for shareholders and other stakeholders.
Evaluation and Improvement	Risk and mitigation evaluations are conducted regularly to review the effectiveness of risk mitigation according to the KPI.
	Improvements will be made to the risk mitigation strategies if they are no longer relevant or if new, previously unidentified risks emerge; this will be incorporated into the risk assessment KPI.

Discussion

This study aims to develop a risk mitigation strategy using Enterprise Risk Management (ERM) for PT XYZ, a company that, to date, lacks a risk mitigation strategy or management for both past and potential risks.

ERM has proven to be effective in reducing the frequency and severity of operational risk events, leading to significant reductions in operational losses (Al-Amri et al., 2016). Established in 2018, PT XYZ is still focused on risk reduction and avoidance, making the COSO ERM framework a suitable method for this research (Prewett et al., 2018), compared to ISO 31000, which focuses more on using risk management to generate business value (Ferreira et al., 2019). The House of Risk (HOR) method is employed to provide quantitative calculations by identifying and prioritizing risk events and agents, as well as designing mitigation strategies (Kusrini et al., 2020).

Upon completion of the study, validation tests were conducted with respondents/expert judgments from PT XYZ, and the proposed mitigation strategies were considered effective. Therefore, the benefit of this research is that it provides valuable information for mitigating risks, enabling the company to implement early preventive actions.

Conclusion

Based on the business process mapping at PT. XYZ, the processes were divided into four sections: marketing, operations, procurement, and finance, corresponding to the company's divisions. The identification process revealed 29 risk events at PT. XYZ.

Risk events and risk agents were measured to determine the ranking of risk agents based on ARP values. This involved assessing the risk severity of events, the occurrence of risk agents, and their correlation values. The ARP values for phase HOR 1 were then calculated and ranked, identifying the 22 risk agents with the highest impact.

Risk mitigation was measured to assess the effectiveness of proposed mitigations for the identified risk agents based on ETD values. This involved determining the correlation values and the difficulty level of implementing the mitigations. The ETD values for phase HOR 2 were then ranked, identifying the 16 most effective risk mitigation actions.

Through qualitative identification using COSO ERM and quantitative analysis with the House of Risk (HOR) model, 16 effective risk mitigation strategies were identified, addressing 19 risk agents and 29 potential risk events at PT. XYZ.

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