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Supply Chain Risk Analysis in the Construction of a Power Barge Using the Failure Mode and Effect Analysis (FMEA) Method

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***Abstract*— The Power Generation Barge functions as a 60 MW power plant for national electrification, particularly in frontier, outermost, and disadvantaged (3T) areas, as well as promoting economic growth and community welfare. However, in the implementation of the Power Generation Barge construction, there are still delays in material delivery, lengthy customs clearance processes, discrepancies in specifications and quantities of goods, difficulties in meeting contract requirements, and financial issues such as insufficient cash flow and delayed payments to suppliers. The objective of this study is to identify risks that influence delays in the procurement phase and minimize the impact of these risks. The method used is *Failure Mode and Effect Analysis (FMEA)* as a preventive measure (*before the event)*. The research results with the highest impact are: Material list estimation calculations revised due to minimum order requirements with a score of 235.98, Length of technical evaluation process (Evatech) with a score of 275.99, Shipping documents frequently delayed by importers with a score of 262.00, and Material status still Eigen Loosing with a score of 169.13. Mitigation strategies implemented include updates from the manufacturer/steel plate and profile supplier regarding minimum order quantities for each size of steel plate and profile, monitoring order deadline timelines, coordinating earlier with vendors/suppliers and shipping agents, and ensuring all necessary documents and requirements are complete for customs clearance and supply chain processes. This reduces the potential for delays.**

Keywords—*Shipbuilding Delays, Supply Chain Risk Analysis, Failure Mode and Effect Analysis, Risk Matrix.*

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I. INTRODUCTION

The Indonesian government launched a 35,000 MW power plant construction program as part of its efforts to enhance national energy sovereignty. PT XYZ Indonesia is supporting this program through the construction of a Power Generation Barge in collaboration with PT A through its subsidiary PT B. This project aims to increase the national electrification ratio, particularly in frontier, outer, and underdeveloped (3T) regions, as well as to promote economic growth and community welfare [12].

The construction of power barge plays a strategic role in advancing the national shipping industry. In addition to driving economic growth through the use of domestic components, this project also absorbs local labor and strengthens supporting industries [12] as well as shipyards that meet the requirements in terms of technology [15, 24] and good planning [16,19,20,21] . However, shipbuilding often faces challenges, particularly during the supply chain or procurement phase before production begins. Key risks that frequently arise at this stage include , material delays [13,25], lengthy customs clearance processes, discrepancies in specifications and quantities of goods, difficulties in meeting contract requirements [8], and financial issues such as insufficient cash flow and delayed payments to suppliers [11]. There have been risk management studies conducted in the shipbuilding industry [3,10,22,23,24] and [7], as well as in ship repair [17,18]. In the *offshore* construction sector, such as the case study of *jacket structure* construction [5], significant root causes of material procurement issues—a classic problem in shipyards—have not yet been identified. A critical issue is the delay in procuring upstream project materials, which must be controlled and anticipated to minimize failures in the downstream shipyard operations.

Based on data from IPERINDO and BRIN, approximately 15–30% of shipbuilding projects experience delays [2], including projects at PT XYZ such as the construction of the Pertamina Oil Tanker and Power Generation Barge. These issues are primarily caused by inadequate risk management.

Delays in the procurement stage have a direct impact on the production process at the shipyard. In the case of Barge at PT XYZ, the master schedule data shows significant delays in the material procurement stage. If the initial stage (upstream) of the project has been delayed, then the subsequent process (downstream) will also be affected, causing cost and time overruns. The novelty of this research lies in the supply chain risk analysis model for the construction of a power

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generation barge as an early anticipation of delays in the procurement of upstream project materials to minimize failures in the downstream shipyard. The focus of risk identification is on the material procurement stage, from the request for quotation process to the material *delivery* process at the shipyard, as well as developing mitigation strategies to minimize construction delays and prevent cost and time overruns from occurring as planned. The method used is the Failure Mode and Effect Analysis (FMEA) [1,26] to identify risks affecting procurement delays and develop mitigation strategies to minimize the impact of risks. The results of this analysis can enhance the effectiveness of shipbuilding project management and reduce the risk of lossefor both the project owner and the shipyard.

II. OVERVIEW OF THE SUPPLY CHAIN FOR THE POWER BARGE

Wu et al. developed a linear mathematical model of tugboat cable force in a study to simulate a berthing maneuver assisted by two tugboats [7]. The mathematical model of 3 DOF maneuvering equations for tugboat handling was developed. The study assumed the vessel had no propelling power and thruster and neglected the hydrodynamic interaction between the ship and the tugs. The derivative equation of MMG was solved using the Runge-Kutta method. This study analyzed the different time domain speeds between the ship and the tugboats, achieving the final speed of 0.45 m/s. This study considered the effect of wind disturbance on the surging, swaying, and yawing motions.

This study is a qualitative descriptive study using a case study approach to gain in-depth understanding of supply chain risks in the construction of a Power Generation Barge in East Java, Indonesia, conducted from March to April 2025. Data was collected through observation, interviews, surveys, and literature reviews, including primary data from direct informants and secondary data from documents, articles, and books. Data analysis began with a literature review on the shipyard industry and risk management, followed by surveys and risk identification based on literature references. Data was analyzed using the *Failure Mode and Effect Analysis (FMEA)* method*,* calculating the *Severity* (severity of failure impact), *Occurrence* (probability of failure), and *Detection* (ability to detect failure) values, followed by calculating the *Risk Priority Number (RPN)* for each risk. Risks with high RPN values are prioritized for mitigation. After obtaining the RPN values, *Risk Mapping* is conducted to map the risk levels, which is one method to determine the priority of risks that need to be mitigated based on *Severity (*impact) and *Occurrence (*probability) values, but without considering *Detection.* To determine the mitigation design, a Focus Group Discussion (FGD) is conducted with management from the Design Department and the Supply Chain Department. The final stage includes discussing the results, conclusions, and mitigation recommendations to prevent or reduce the impact of risks in future shipbuilding projects.

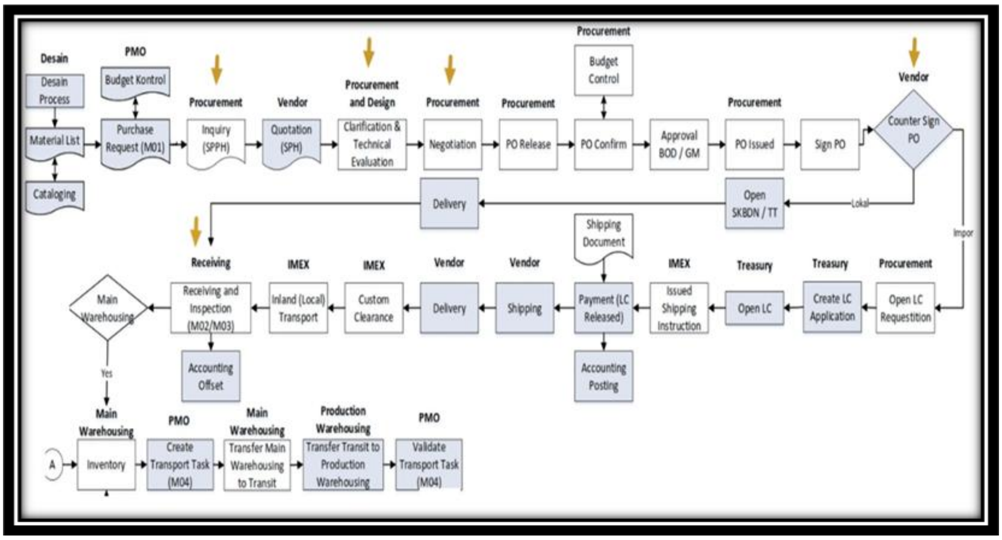

Figure. 1. Supply Chain Process Flow

A. Project Management

Project management can be defined as a process of planning, organizing, leading, and controlling a project by its members, utilizing resources as efficiently as possible to achieve predetermined objectives. The basic functions of project management include managing scope, time, cost, and quality. Proper management of these aspects is the key to the success of a project [7]. Project management helps to clarify the boundaries regarding the tasks, authority, and responsibilities of the parties involved in the project, both directly and indirectly, so that there is no *overlap in* tasks and responsibilities. Various project management functions can be realized clearly and structurally, so that the ultimate goal of a project will be easily achieved [14], namely:

1. On Time, which relates to the timeliness of the project's completion according to the plan.
2. Quantity, which relates to the accuracy of the quantity of materials according to the plan.

3. Quality on Time, which relates to the accuracy of the quality of materials in accordance with the plan.
4. Cost-Effective, this relates to the accuracy of the financial costs of the quality of materials in accordance with the planned budget.
5. No social unrest with the surrounding community, which relates to safety during the project in accordance with the planning permit.
6. The successful implementation of K3 is related to safety during the project in accordance with K3 regulaations so that employees are safe and comfortable in accordance with the planning permit.

Project implementation requires solid and structured coordination and cooperation between organizations. This is the key to ensuring that the final project objectives are completed according to the planned *schedule*.

B. Risk Assessment

Based on [6] terminology for risk studies, these include risk analysis—estimating risks from basic activities carried out. Risk assessment - a review for acceptance based on comparison with risk standards or risk criteria, and the evaluation of various risk reduction measures. Risk management - the process of selecting appropriate risk reduction measures and implementing them in activity management.

Risk assessment in [6] is a technique for accepting risk based on comparison with risk standards or risk criteria, and testing various risk reduction measures. Risk assessment can be applied in qualitative, semi-quantitative, and quantitative approaches, and project managers need to decide which approach is appropriate for the work being done, with the aim of risk reduction. The first step in *risk assessment* is to identify the hazards present. Then, the risks arising from them are evaluated qualitatively, semi-quantitatively, or quantitatively. Reducing the risk level is permitted if the risk exceeds the "screening criteria." After the necessary steps have been identified, the functional requirements of these steps must be defined. Generally, the qualitative approach involves applying a rating scale based on insight (no additional resources or expertise are required). Conversely, the quantitative approach is the most resource- and expertise-intensive, but it has the potential to provide the most detailed understanding and the best foundation for significant expenditures involved. The semi-quantitative approach lies between these two approaches. *Risk assessment* is currently a proven technology for operators to address greater hazards in a structured manner and to ensure that risks have been reduced to an appropriate cost level effectively. The following risks were analyzed in this study

TABLE 1.
LIST OF RISKS

Group	No	Risk List	Source
Material Delays	1	Late submission of material request forms.	(Salsabila & Liperda, 2023)
	2	Long lead time from suppliers	
	3	Difficulty in obtaining quotes from suppliers and their competitors	
	4	Lengthy supplier approval/selection process	
	5	Delays in down payment and final payment to suppliers from the Finance Department	
	6	Supplier default (delay)	
	7	Insufficient monitoring after the purchase order is issued.	
Long customs clearance process	8	Imported materials subject to prohibitions and restrictions (Lartas)	(Nazla & Vikaliana, 2024)
	9	Delays in PIB payments from the Finance Department	
	10	Subject to Red Channel	
	11	Certification of materials is required	
	12	Lengthy processing/import permit process due to Lartas or changes in import regulations.	
Goods Specifications Not Compliant	13	The Material Request Form does not specify clear specifications	(Ramadhan & Supomo, 2024)
	14	Lack of coordination between the purchasing department and the user department	
	15	Never purchased the same material before	
	16	Supplier default (materials delivered do not match the specifications in the PO)	
Quantity of materials does not match	17	The Material Request Form states an incorrect quantity	(Ramadhan & Supomo, 2024)
	18	Subject to minimum order from Supplier/Manufacturer	
	19	Supplier default (materials delivered do not match the quantity on the PO)	

III. METHOD

FMEA is an analysis technique that combines technology and human experience to identify the causes of product or process failures and plan for their elimination. FMEA activities consist of [3]:

- Identifying and evaluating potential product failures and their effects.
- Identifying actions that can eliminate or reduce the likelihood of potential failures occurring.
- *Documenting the process.*

FMEA can be considered a preventive measure (before the event) because FMEA seeks to eliminate and reduce the possibility of failure from the cause, thereby preventing failure from recur in the future. There are three steps in performing the FMEA method [3]:

1. Identify Failures: identifying errors in a process, along with the causes and effects of those errors.
2. Prioritize Failures: using the RPN (Risk Priority Number) calculation, the highest errors/risks are identified.
3. Reduce Risk: reduce risks through various methods.

The basic philosophy of FMEA is: "prevent before it happens." FMEA is highly effective when used inquality management systems for any type of industry. To determine the priority of a failure mode, it is necessary to first define Severity, Occurrence, and Detection, where the highest RPN result indicates the highest risk. Severity (S) Is the level of severity of the impact of a failure mode. A failure impact is defined as the result of a failure mode on the system's function as perceived by the user. Each impact is assigned a severity (S) value ranging from 1 (no danger) to 10 (critical). This value helps prioritize failure modes and their impacts. Table 2 explains the criteria and descriptions of the Severity (S).

TABLE 2.
SEVERITY CRITERIA

Score Value	Criteria	Description
10 – 9	Very high	Significant impact and >20% impact on *the critical path*
8 – 7	High	Significant impact and 10%-20% impact on *the critical path*
6	Moderate	5%-10% impact on *the critical path*
4	Low	Impact < 5% on *the critical path*
2	Very low	No significant impact

Source: (Arifandy, et al., 2023)

Occurrence (O)

This refers to how often a failure mode occurs. At this stage, it is necessary to examine the causes of a failure mode and how often it occurs. Table 3 explains the criteria and descriptions of the *Occurrence* (O) value of a risk event.

TABLE 3.
OCCURRENCE CRITERIA

Score Value	Criteria	Description
10	Very likely to occur	An event is likely to occur in almost all conditions
8 – 7	It is likely to occur	An event that will occur under certain conditions
6 – 5	Equal chance of occurring or not	An event that may or may not occur under certain conditions
4	The possibility of not to occur	An event may occur under certain conditions , but the likelihood of it happening is low
2 – 1	Very unlikely to occur	An event that is impossible to occur under certain conditions

Source: (Arifandy, et al., 2023)

Detection (D)

It is how capable we are of detecting a potential mode of failure. A high detection value [1] indicates that failures will escape detection with a high probability, or in other words, the ability to detect is low. Table 4 explains the criteria and description of the *Occurrence* (O) value of a risk event.

- Descriptive/qualitative research data was collected through questionnaires in surveys, interviews, and observations [27]. The research process is one of the focuses of qualitative research, so the process is more important than the final results. Qualitative research aims to find out the reasons how and why a problem arises in the research. Qualitative research involves interpretive techniques that delve deeply into an issue until the researcher is able to describe, interpret the data, and draw conclusions [27]. This study used the Barge Power Plant in Surabaya, East Java, as its research object during the period of March 2025 to April 2025.
- After obtaining data from the distribution of questionnaires to the supply chain, including buyers, assistant managers, and procurement managers, the Risk Priority Number (RPN) was calculated. The RPN was obtained from the calculation of Severity x Occurrence x Detection. The next step was to rank the RPN from the highest to the lowest value. Risk events with high RPN indicate that these risks must be addressed to prevent recurrence or reduce their impact. Mitigation measures are therefore required for these risk events. At this stage, mitigation measures were identified through Focus Group Discussions (FGD) with managers and several members of the relevant departments. The results of the FGD were a list of various proposed mitigation measures for risks with the highest RPN

TABLE 4.
DETECTION CRITERIA

Score Value	Criteria	Description
10	Almost no detectable	*Hazards Analysis*, *Job Safety Analysis*, *Preliminary Hazard Analysis*, work plans or procedures are almost impossible to detect risks
8 – 7	Slight possibility of detecting	*Hazards Analysis*, *Job Safety Analysis*, *Preliminary Hazard Analysis*, plans or work procedures have a small chance of detecting risks
6 – 5	Moderate *Moderate likelihood* of detecting	*Hazards Analysis*, *Job Safety Analysis*, *Preliminary Hazard Analysis*, work plans or procedures have a *moderate* likelihood of detecting risks
4	High likelihood of detecting	*Hazards Analysis*, *Job Safety Analysis*, *Preliminary Hazard Analysis*, work plans or procedures have a high likelihood of detecting risks
2	Very likely detect	*Hazards Analysis*, *Job Safety Analysis*, *Preliminary Hazard Analysis*, work plans or procedures are very likely to detect risks

Source: (Arifandy, et al., 2023**)**

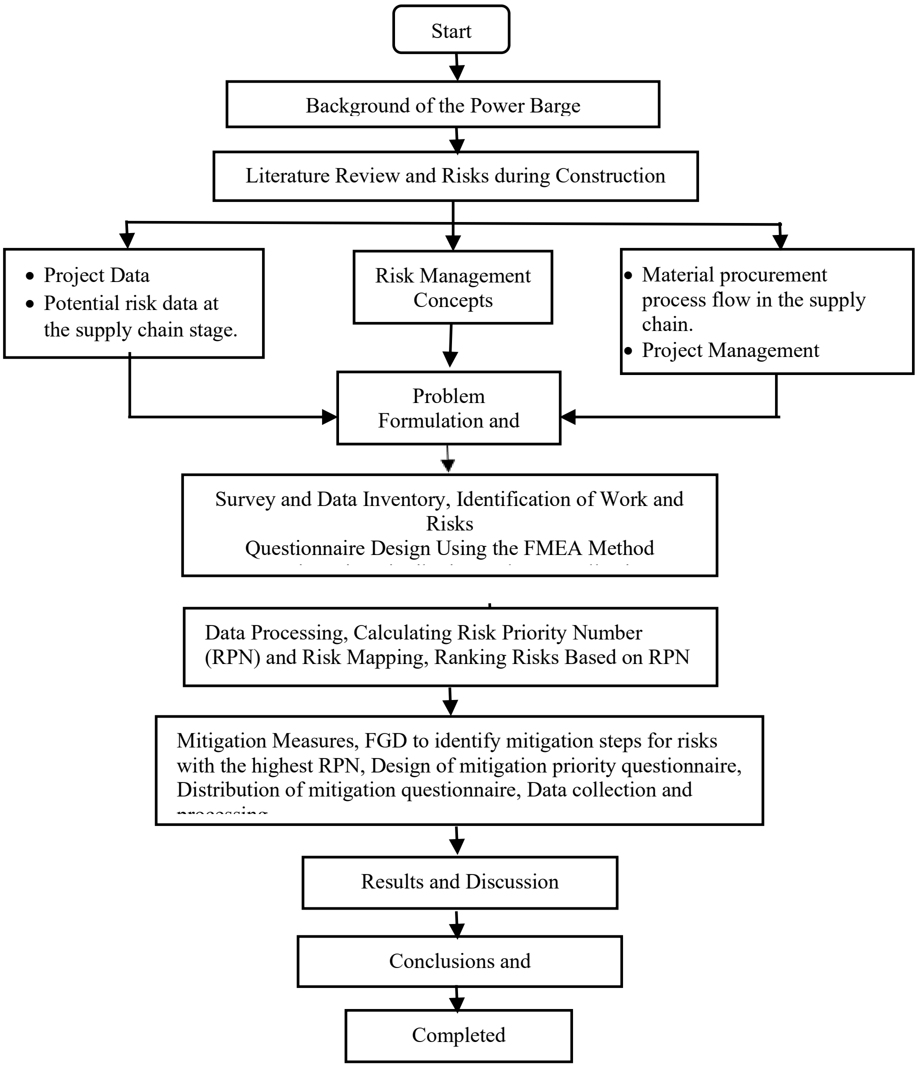

Figure. 2. Research Flow Char

- The data obtained includes both primary and secondary data. The data sources in this research consist of primary and secondary data sources. Secondary data collection involves data or documents that have been provided or processed by other parties, such as articles, books, and websites. Primary data is data obtained directly from the main or primary informants, such as interview results. In the construction of power generation ships at the Surabaya shipyard, research was conducted involving direct data collection from the field. Risk identification was carried out using references from several literature sources, namely: [8,13]. The data was obtained through observation, interviews with experts, and group discussions. The results of these activities were then used to identify various risks that could hinder the shipbuilding process.

IV. RESULTS AND DISCUSSION

A. *Risk Identification*

Risk identification for the Supply Chain in this Barge Power Plant construction project was obtained through interviews and *brainstorming* sessions with industry practitioners at the level of Division Heads, Department Heads, Workshop Heads, and Supervisors/staff with experience in their respective departments. From the results of these interviews and *brainstorming* sessions, 40 risk sources were identified for the four sections studied. The Material Request Issuance (Design) section had 10 risk sources, as shown in Table 5. The Material Procurement section had 12 risk sources, as shown in Table 6. The Imported Material Procurement department had 11 risk sources, as shown in Table 3, and the Material Receiving department had 7 risk sources, as shown in Table 7. These risk sources can be grouped into 4 risk events in each department, referencing several literature sources [7,26].

TABLE 5.
CAUSES OF DELAYS IN MATERIAL REQUEST ISSUANCE (M01)

Type of Work: Material Request Issuance Process (M01)								
No	Risk Category	Failure Mode	Code	Cause of Failure	Rating Assessment			RPN
					S	O	D	
1	Material List Estimation Calculation	Supporting documents are incomplete	A	Key Plan and Yard Plan have not been approved yet. Class	6	5.5	5.69	216.78
			A2	The Steel Plan development process is not yet complete.	5.66	5.31	5.51	165.78
			A3	The Material List estimate has been revised due to changes in the Yard Plan and Steel Plan drawings.	6	4.91	5.54	163.4
			A4	The process of inputting material estimates into PDM (Product Data Manufacture) has not been completed.	5.43	5.43	5.43	159.98
			A	The Material List estimate has been revised due to the minimum order requirement from the supplier/manufacturer.	6.71	5.97	5.89	235.98
			A6	The material specifications mentioned in the master contract are unclear or lack detail.	5.69	4.31	5.54	135.97
2	Material Request Issuance (Form M01)	Duration of M01 issuance process	A7	An error occurred in the budget allocation posting that does not match the Budget HPP.	5.14	3.2	4.69	77.80
			A8	HPS (Estimated Price) has not been published because the HPS team is still in the process of sourcing materials.	5.69	4	4.46	101.37
			A9	The delivery time of materials at the shipyard does not match the planned usage schedule (used date).	5.40	4.69	3.31	83.86
			A10	The HPS (Estimated Price) published exceeds the budget specified in the HPP.	5.4	3.54	3.54	67.78

Note: Red indicates the highest RPN value, and green indicates the lowest RPN value

B. *Research Findings*

Based on the above risk list, Questionnaire I was developed to determine *the severity*, *occurrence*, and *detection* values for each risk event in the four sections studied. The *severity*, *occurrence*, and *detection* values were determined using the criteria below, adopted from [26] and adapted to the conditions of the shipbuilding project.

TABLE 6.
CAUSES OF DELAYS IN THE MATERIAL PROCUREMENT PROCESS

Type of Work: Material Procurement Process.								
No	Risk Category	Form of Failure	Code	Cause of Failure	Rating Assessment S	O	D	RPN
1	Vendor/Supplier Selection	The bidding, evaluation, and tender process takes a long time	B1	The length of time it takes for vendors/suppliers to respond when asked to submit bids for material procurement.	7.03	5.2	5.14	187.96
			B	Difficulty in finding a comparable supplier for materials with specifications that are not commonly available in the market.	6.00	5.09	6	207.5
			B3	Vendor specified in the Maker List but unable to fulfill the requested materials/equipment according to the Material List	7.51	4.89	4.7	174.1
			B	The length of the Technical Evaluation Process (Evatech) due to the involvement of many parties, namely Design, Owner, Maker, Class, and Supply Chain.	7.06	6.74	5.8	275.99
			B5	Length of Commercial Evaluation Process (Price Negotiation and Payment Terms)	6.63	6.20	5.51	226.62
		The bidding, evaluation, and tender process takes a long time	B	The negotiated price with the vendor exceeded the HPS, resulting in the tender failing and unable to proceed further.	7.8	4.8	4.49	169.56
			B7	The delivery lead time offered by the vendor/supplier does not match the project's target date.	5.49	5.43	5.2	154.85
			B	The Board of Directors requested a re-tender process for certain reasons.	6.20	4.20	4.69	122.02
2	Purchase Order (PO) Issuance	Duration of PO issuance process	B9	Drafting the contract (PO) takes a long time.	6.17	5.03	4.46	138.32
			B10	The review and contract signing process (PO) from vendors/suppliers takes a long time.	6.00	4.54	3.63	98.90
			B11	The process of signing contracts (PO) by the President Director or Board of Directors takes a long time.	6.14	4.97	4.94	150.95
			B12	The process of amending the contract due to changes in the contract clauses takes a long time.	5.14	4.63	4.31	102.70

Note: Red indicates the highest RPN value and green indicates the lowest RPN value

TABLE 7.
CAUSES OF DELAYS IN THE IMPORTED MATERIAL PROCUREMENT PROCESS

Type of Work: Imported Material Procurement Process.								
No	Risk Category	Form of Failure	Code	Cause of Failure	Rating Assessment S	O	D	RPN
1	Imported Material Procurement Process	The process of shipping imported materials takes a long time	C1	Shipping materials by sea (sea freight) takes a long time (Europe 45 days, Asia 17 days, and ASEAN 8 days)	6.3	5.37	2.31	78.85
			C2	For the shipment of imported materials using the CIF (Cost, Insurance, Freight) scheme, the price is higher than the FOB (Free On Board) scheme.	5.26	4.66	2.86	69.95
			C3	Shipping documents are often sent late by importers, so that sometimes the ship has already arrived at the port but the documents have not yet been received, which could result in demurrage and storage fees.	7.6	5.86	5.89	262

Type of Work: Imported Material Procurement Process.								
No	Risk Category	Form of Failure	Code	Cause of Failure	Rating Assessment S	O	D	RPN
		The customs clearance process at Customs requires many requirements and takes a long time.	C4	Processing applications for import duty and tax exemption facilities (SP01) takes a considerable amount of time, namely 8 working days.	6.54	5.57	4.8	177.06
			C5	Length of import processing/permit due to Lartas or changes in import regulations.	7.34	5.37	6.46	254.68
			C6	Imported materials were subject to red channel inspection due to missing import documents.	7.14	4.46	4.49	142.81
			C7	Imported materials incurred demurrage charges due to delays in pickup after unloading from the ship.	6.63	4.8	4.46	141.81
			C	Imported materials incurred storage costs because the imported goods were stored at the port for too long, exceeding the specified time limit.	6.2	4.23	4.03	105.62
			C9	Application for Eigen Lossing (Storage Permit) at the importer's warehouse; goods may be transported but may not be unsealed or used.	5.97	4.34	3.5	91.14
			C10	Processing of Goods Release Approval Letters (SPPB) takes a considerable amount of time (7 days)	5.97	4.51	5	134.78
			C11	Processing of the request letter to open the seal takes a considerable amount of time (4 days)	5.51	4.14	4.94	112.92

Note: Red indicates the highest RPN value and green indicates the lowest RPN value

TABLE 8.
CAUSES OF DELAYS IN THE MATERIAL RECEIVING PROCESS

Type of Work: Material Receiving Process								
No	Risk Category	Failure Mode	Code	Cause of Failure	Rating Assessment S	O	D	RPN
1	Material Receiving Process at the Shipyard Warehouse	Transportation from Port to Shipyard	D1	The process of unloading materials at the port takes a long time.	6	4.8	4.66	136.52
			D2	Material delivery from the port to the shipyard is often carried out outside working hours (at night).	4.31	3.94	3.23	54.92
			D3	The unloading process at night is very ineffective due to limited lighting.	4.83	4.91	3	90.1
		Material Receiving Inspection	D4	Material Certificates (COO, COM, Class) have not been received by the Shipyard.	5.31	5.31	5.80	163.80
			D	The material status is still Eigen Loosing, so it is not permitted to open the seal and conduct an inspection.	6.83	5.86	4.23	169.13
			D6	The Material Receipt Report cannot be issued yet because the status is still Eigen Loosing.	5.00	4.8	3.5	85.53
			D7	Non-performing supplier (materials delivered did not meet the specifications in the PO)	5.86	4.03	6.43	151.69

Note: Red indicates the highest RPN value and green indicates the lowest RPN value

Risk Mapping

Risk level mapping is one way to determine the priority of risks that need to be mitigated based on *Severity* (impact) and *Occurrence* (probability) values, but without using *Detection*. High-impact projects cause the failure of every existing risk, which is then mapped into a risk level table and displayed in red and given the highest priority in the risk management phase.

Risk Level Mapping	Severity (Impact)				
Occurrence (Probability)	**1**	**2 - 3**	**4**	**6**	**9**
1	*Low*	*Low*	*Low*	*Medium*	*Med*
2 - 3	*Low*	*Low*	*Medium*	*Medium*	*High*
4 - 5	*Low*	*Low*	*Medium*	*High*	*High*
6 - 8	*Low*	*Medium*	*Medium*	*High*	*High*
9 - 10	*Low*	*Medium*	*High*	*High*	*High*

Figure. 3. Risk Level Mapping Scale (Source: Ariany et al., 2023)

Risk levels in the matrix are presented as whole numbers, so values for severity and occurrence that are greater than or equal to (≥ 0.5) are rounded up. Decimal values below (< 0.5) are rounded down. These are then arranged in a 5 x 5 matrix as follows:

Risk Level Mapping	Severity (Impact)				
Occurrence (Probabilities)	**1**	**2 - 3**	**4**	**6**	**9–10**
1					
2 - 3			***A7***		
4 - 5			***A4, A9, A10***	***A2, A3, A6, A8***	
6 - 8				***A1, A5***	
9 - 10					

Figure. 4. Risk Mapping for Material Request Issuance (M01)

Based on the figure above, there are 6 high risks as described in Table 9.

Based on the figure above, it shows that there are 10 risks in the high risk category, as shown in Table 10.

TABLE 9.
RISK CATEGORY A

Code	Cause of Failure
A	Key Plan and Yard Plan not yet approved Class
A	The Steel Plan creation process has not been completed
A	The Material List estimate has been revised due to changes in the Yard Plan and Steel Plan drawings.
A5	The Material List Estimate has been revised due to the minimum order requirement from the supplier/manufacturer.
A6	The material specification data mentioned in the main contract is unclear or lacks detail.
A8	The HPS (Estimated Price) has not been published because the material sourcing process is still ongoing.

Risk Level Mapping	Severity (Impact)				
Occurrence (Probabilities)	**1**	**2 - 3**	**4–5**	**6**	**9–10**
1					
2 - 3					
4 - 5			***B7, B12***	***B1,B2,B3,B5,B6,B8,B9, B10,B11***	
6 - 8				***B4***	
9 - 10					

Figure. 5. Mapping Severity and Occurrence in the Material Procurement Process

TABLE 10.
RISK CATEGORY B

B1	The length of time it takes for vendors/suppliers to respond when asked to provide quotes for material procurement.
B2	Difficulty in finding a comparable supplier for materials with specifications that are not commonly available in the market.
B3	Vendors listed in the Maker List but unable to supply the requested materials/equipment as per the Material List.
B4	Lengthy Technical Evaluation Process (Evatech) due to involvement of multiple parties: Design, Owner, Maker, Class, and Supply Chain.
B5	The duration of the Commercial Evaluation Process (price negotiation and payment terms)
B6	The negotiated price with the vendor exceeds the HPS, resulting in the tender failing and unable to proceed further.
B8	The Board of Directors requested a re-tender process for certain reasons.
B9	The preparation of the contract draft (PO) takes a long time.
B10	The review and signing process for the contract (PO) from the vendor/supplier takes a long time.
B11	The process of signing the contract (PO) by the CEO or Board of Directors takes a long time.

Risk Mapping Level	**Severity (Impact)**				
Occurrence (Probabilities)	**1**	**2 - 3**	**4**	**6**	**9**
1					
2 - 3					
4 - 5			***C2, C8, C9, C10***	***C1, C5, C6, C7, C11***	
6 - 8				***C3, C4***	
9 - 10					

Figure. 6. Mapping Severity and Occurrence in the Import Material Procurement Process.

Based on the figure above, there are 7 high risks. As follows:

TABLE 11.
RISK CATEGORY C

C1	The delivery time for materials by sea freight is lengthy (Europe: 45 days, Asia: 17 days, and ASEAN: 8 days)
C3	Shipping documents are often delayed by importers, so that sometimes the ship has already arrived at the port but the documents have not yet been received, which could result in demurrage and storage fees.
C4	Processing the application for import duty and tax exemption facilities (SP01) takes a considerable amount of time, namely 8 working days.
C5	The length of the import processing/permit process due to Lartas or changes in import regulations.
C6	Imported materials are subject to red channel inspection due to missing import documents.
C7	Imported materials incur demurrage charges due to delays in pickup after unloading from the ship.
C11	Processing of the Open Seal Request Letter takes a considerable amount of time (4 days).

Risk Level Mapping	**Severity (Impact)**				
Occurrence (Probabilities)	**1**	**2 - 3**	**4**	**6**	**9**
1					
2 - 3					
4 - 5			***D2, D3, D4, D6, D7***	***D1***	
6 - 8				***D5***	
9 - 10					

Figure. 7. Mapping Severity and Occurrence in the Material Receiving Process.

Based on the figure above, the two highest risks are D1 and D3, which are the material unloading process at the port takes a long time and the material status is still Eigen Loosing, so it is not permitted to open the seal and conduct an inspection.

Mitigation Strategy

Based on the Risk Priority Number (RPN) calculations for each risk event and the risk mapping results identified based on severity (impact) and occurrence (probability) values, the next step is to develop mitigation strategies to prevent the risks from recurring. The mitigation strategies that can be implemented are as follows:

TABLE 12.
MITIGATION STRATEGIES

Code	Cause of Failure	Mitigation Steps
		Material Request Issuance (M01)
A	The Material List estimate has been revised due to the minimum order requirement from the supplier/manufacturer.	1. Search for updated data references related to minimum orders for each size of steel plate and profile at the manufacturer/manufacturing plant. 2. Request the Design team to perform more accurate calculations to avoid excessive size variations. 3. The Supply Chain Team must coordinate with all ongoing projects to check the Material List in each project and conduct a joint material procurement process (PO) for the same type and size.
		Material Procurement Process
B2	The length of the Technical Evaluation Process (Evatech) due to the involvement of multiple parties, including Design, Owner, Manufacturer, Classification Society, and Supply Chain.	1. The Supply Chain team must continuously monitor and set deadlines for relevant parties to complete the technical evaluation of materials to be ordered. 2. The Project Team must assist in coordinating with all parties to expedite the technical evaluation process, particularly with the Owner regarding the master contract that has been agreed upon.
		Imported Material Procurement Process
C3	Shipping documents were delayed by the importer, potentially resulting in demurrage and storage fees.	1. The Supply Chain Team must continuously coordinate with the Vendor/Supplier and Shipping Agent well in advance before confirmation that the materials are ready to be shipped from the Supplier at the origin (country of origin). 2. Coordinate with all relevant parties regarding the completeness of documents and requirements needed for the customs clearance process at the Customs Office.
		Material Receipt at the Shipyard
D4	The material status is still Eigen Loosing, so it is not permitted to open the seal and conduct an inspection ( ).	Coordinate with the IMEX department to continuously monitor the submission of the seal opening request letter at Customs.

Based on the results of the identification and analysis of risk events that have been carried out on the Barge Power Plant construction project undertaken by PT. XYZ, from the 4 sections studied, there were 8 forms of failure (Risk Events) and 40 causes of failure (Risk Agents). These include Material Request Issuance (M01) = 2 risk events and 10 risk agents. In material procurement = 2 risk events and 12 risk agents, and imported material procurement = 2 risk events and 11 risk agents, as well as material receipt = 2 risk events and 7 risk agents. The highest RPN (Risk Priority Number) calculation result is the most prioritized risk to address because it involves many external factors such as Suppliers, Shipping Agents, Customs, and Class Owners. In the four sections studied, four risk events (risk agents) were identified that significantly impact the delay in the construction of the Power Generation Barge: Material List Estimation underwent revision due to minimum order requirements from suppliers/manufacturers, with an RPN value of 235.98

- The prolonged Technical Evaluation Process (Evatech) due to the involvement of multiple parties, including Design, Owner, Maker, Class, and Supply Chain, with an

RPN value of 275.99

- Shipping documents were delayed in being sent by the importer, potentially resulting in demurrage and storage fees, with an RPN value of 262.00
- The material status is still Eigen Loosing, so it is not permitted to open the seal and conduct an inspection, with an RPN value of 169.13

Risk incident: The material list estimation calculation was revised due to minimum order requirements from the steel plate and profile manufacturer, which significantly impacted other risk incidents. The material procurement process cannot be carried out if the material list and material procurement form (M01) have not been issued. The Technical Evaluation Process (Evatech) conducted by the buyer and Design with the Supplier requires intensive coordination to avoid errors in material selection. The process of shipping materials from abroad (import) requires a long time and numerous requirements; acceleration measures are needed. This includes ensuring that the materials can be used immediately upon arrival and are not held up for too long due to the Eigen Loosing status by Customs. Risk incidents The estimation of the material list is subject to revision due to minimum order requirements from steel plate and profile manufacturers, which significantly impact other risk incidents. The procurement process cannot be initiated if the material list and procurement form (M01) are not issued. The Technical Evaluation Process (Evatech) conducted by the procurement officer and Design team with the Supplier requires intensive coordination to avoid errors in material selection.

The process of shipping materials from abroad (import) requires a long time and numerous requirements; acceleration measures are needed. This includes ensuring that materials can be used immediately upon arrival and are not held up for too long due to customs clearance issues.

Mitigation strategies that can be applied to reduce the impact of risks on the Barge Power Plant construction project, particularly during the supply chain (procurement) phase, include:

- Obtaining updated data references from steel plate and profile manufacturers regarding minimum order quantities for each size of steel plate and profile, requesting the Design Team to perform more accurate calculations to avoid excessive size variations, and having the Supply Chain Team coordinate with all ongoing projects to review material lists for each project and conduct joint procurement processes (PO) for the same type and size of materials.
- The Supply Chain must continuously monitor and set deadlines for relevant parties to complete the technical evaluation of the materials to be ordered. The Project Team must assist in coordinating with all parties to expedite the technical evaluation process, particularly with the Owner regarding the agreed master contract.
- Early coordination with Vendors/Suppliers and Shipping Agents responsible for shipping materials from the country of origin (Origin) to ensure shipping documents are prepared in advance and avoid delays.
- Coordinate with all relevant departments regarding the completeness of documents and requirements needed for the customs clearance process at Customs and the Import-Export (IMEX) Supply Chain department must continuously monitor updates on the process at Customs. In this study, FMEA was used, so that for the highest risk priority number, special treatment is needed to reduce the probability value, thereby controlling the significant impact. For future research, quantitative discussions using several system dynamics software or simulations are needed to ensure precise control.

V. CONCLUSION

The highest RPN (Risk Priority Number) calculation results indicate the most critical risks to address, as they involve numerous external factors such as suppliers, shipping agents, customs, and class owners. In the four sections studied, four risk events (risk agents) were identified that significantly impact the delay in the construction of the power barge project, including revisions to the Material List estimate due to minimum order requirements from suppliers/manufacturers, the length of the Technical Evaluation Process (Evatech) due to the involvement of multiple parties such as design, owner, manufacturer, class, and supply chain, and shipping. Documents were delayed in being sent by the importer, potentially resulting in demurrage and storage fees, and the material status remained "eigen loosing," meaning it was not permitted to open the seals and conduct inspections.

This requires emphasis from management in updating data, monitoring, evaluating, and coordinating with relevant parties in addressing these risk agents so that project failures can be anticipated.

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REFERENCES

[1] Arifandy, I., Daga, R., & Didiharyono, 2023. Analysis of the Government Procurement System at the South Sulawesi Provincial Procurement Bureau Through the Reviu Application. *Jurnal Sains Manajemen Nitro,* 2(2), pp. 122-137.

[2] BRIN, 2023. *Investment Project Ready to Offer,* Jakarta: National Research and Innovation Agency.

[3] Carlson, 2020. *Effective FMEAs: Achieving Safe, Reliable, and Economical Products and Processes Using Failure Mode and Effect Analysis.* New Jersey: John Wiley & Sons Inc.

[4] Crispim, J., Fernandes, J., & Rego, N., 2020. Customized Risk Assessment in Military Shipbuilding. *Reliability Engineering & System Safety,* 1(1), pp. 1–35.

[5] Dwisetiono & Fairussihan, J., 2022. Analysis of Occupational Safety and Health (OSH) Risks in Ship Repair Processes at PT Dock dan Perkapalan Surabaya Using the HIRARC Method (Hazard Identification, Risk Assessment, and Risk Control). *Jurnal Hexagon,* 3(1), pp. 10-16.

[6] Gray, 2020. Project Management. *LPFE,* pp. 19-30. Kapaldanlogistik, 2023. *Ship Science and Logistics.* [Online] Available at: https://www.kapaldanlogistik.com/2023/05/cara-dan-proses-membangun-kapal.html

[7] Kurniawati & Pribadi, 2008. Material Supply Chain in the Shipbuilding Industry. *PSP Bulletin,* pp. 38-58.

[8] Nazla, A. & Vikaliana, R., 2024. Risk Analysis in the Procurement Process of Goods in Indonesian Oil Companies Using the House of Risk Approach. *Journal InTent,* 7(1), pp. 33-40.

[9] Palippiu, H., Wahyudiin & Rahmat, N., 2021. Risk Analysis of Shipbuilding Using the Consequence/Probability Matrix Technique. Journal of Marine Science and Technology Innovation, 2(5), pp. 86-91.

[10] Putri, H., Mulyatno, I., & Manik, P., 2023. Risk Management Study Using FTA and FMEA Methods Due to Delays in the KM Sabuk Nusantara 72 Pioneer Ship Construction Project. Journal of Marine Engineering, 11(2), pp. 1-12.

[11] Ramadhan, R. & Supomo, H., 2024. Cost Risk Analysis on the Continuation of Ship Construction That Has Been Suspended for a Long Time. ITS Engineering Journal, 13(2), pp. 29-35.

[12] Rianto, E., 2024. PT XYZ Indonesia. [Online] Available at: https://www.pal.co.id/pt-pal-indonesia-kebut- persiapan-performance-test-bmpp-nusantara-ii-dukung-persiapan-nataru-2025/ \

[13] Salsabila, D. & Liperda, R., 2023. Risk Analysis in the Service Procurement Process at RU III Using the House of Risk (HOR) Approach. Infotech Journal, 9(1), pp. 270-278.

[14] Suwinardi, 2020. Project Risk Management. Orbith, pp. 145-151.

[15] Mohammad Imron Mustajab, Buana Ma'ruf, Satrio Samudro Aji Basuki, Erwien Yuliansyah Putra, Bambang Irawan, Intan Baroroh, Sutrisno Sutrisno, Deshinta Arrova Dewi., 2025. Prioritizing Key Internal Strategic Factors for Long-Term Competitiveness of Medium-Sized Shipyards Using the DEMATEL-ANP Method. Journal of Engineering Results 25 (2025) 103996

[16] Zulfaidah Ariany, Trika Pitana, Iwan Vanany, 2024. Integration of FMEA and Bayesian Network Method for Risk Assessment of Component Delays in Ferry Ship Construction. Journal (2024) (EUREKA: Physics and Engineering) Number 1.

[17] Intan Baroroh, Galuh Valent Setiawan, Ali Azhar, Didik Hardianto, Akhmad Basuki Widodo. (Received: August 10, 2023 / Revised: August 15, 2023 / Accepted: August 16, 2023). Risk Analysis of Delay in Ship Repair KM Binaiya with Bayesian Network Method. International Journal of Marine Engineering Innovation and Research, Vol. 8(3), Sept. 2023. 449-459 (pISSN: 2541-5972, eISSN: 2548-1479).

[18] Intan Baroroh, Ndaru Gilang Ramadhan, Didik Hardianto, Tri Agung Kristiyono. (Received: November 14, 2023 / Revised: November 15, 2023 / Accepted: November 16, 2023). Risk Evaluation of Repair Delays with The Failure Modes and Effects Analysis (FMEA) Method. International Journal of Marine Engineering Innovation and Research, Vol. 8(4), Dec. 2023. 605-615 (pISSN: 2541-5972, eISSN: 2548-1479).

[19] Intan Baroroh, I.M. Ariana, A.A.B. Dinariyana. (Received: July 9, 2024 / Revised: August 2, 2024 / Accepted: August 9, 2024). Implementation of Material Control in Tugboat Ship Building Using the Lot For Lot (LFL) Method Case Study: (PT. PMP). International Review of Mechanical Engineering (I.RE.M.E) Vol. 16, No. 6 ISSN 1970–8734. June 2022 .

[20] Wenny Prawati, Intan Baroroh, (Received: May 11, 2025 / Revised: June 3, 2025 / Accepted: June 23, 2025 / Available Online: June 30, 2025). Hospital Auxiliary Vessel Fore Part Zone Planning to Improve Productivity with Precedence Diagram Method International Journal of Marine Engineering Innovation and Research, Vol. 10(2), June, 2025.525–536 (pISSN: 2541-5972, eISSN: 2548-1479).

[21] Intan Baroroh, Didik Hardianto, Siswo Hadi Sumantri, Sutjipto, Tri Agung Kristiyono. (Received: July 9, 2024 / Revised: August 2, 2024 / Accepted: August 9, 2024). Risk Evaluation Concept of Supply Chain in Modular Construction Shipbuilding.

[22] Intan Baroroh, Buana Ma'ruf, Minto Basuki, Didik Hardianto, Tri Agung Kristiyono. Engine Room Module Installation System Risk Analysis Based on Bayesian Network. International Journal of Technology 15(1) 75-86 (2024).

[23] Minto Basuki, Djauhar Manfaat, Setyo Nugriho, AAB Dinariyana. (Received: August 2012 / Revised: April 2013 / Accepted: December 2013). Probabilistic Risk Assessment of the Shipyard Industry Using the Bayesian Method. International Journal of Technology (2014) 1:88-89 ISSN 2086-9614.

[24] Minto Basuki, Teguh Setyoko. Operational Risk in the Construction Process of FPB 38 Ship Using Aluminum Material at PT. PAL Indonesia. www.researchgate.net/publication/318866799. December 2009

[25] Ariany, Z., Pitana, T., & Vanany, I. Risk Assessment of New Ferry Ship Construction in Indonesia Using the Failure Mode Effect and Analysis (FMEA) Method. Journal of Applied Engineering Science (2023). 21, 3, pp. 872–883, 12 pp. [26] Liu, H.T., & Yieh-Lin, T, "A fuzzy risk assessment approach for occupational hazards in the construction industry", Safety Science, 2012 [27] Sugiyono. Quantitative, Qualitative, and R&D Research Methods. Bandung: CV Alfabeta, 2022. 1405, 2022; Statistics for Research.

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