



Risk Evaluation Of The Shipyard Supply Chain Process On Ship Repair With The House Of Risk Matrix Method



Hanif Ardhio Firmansyah^a, Intan Baroroh^a, Ali Azhar^{a*}

^aNaval Architecture, Faculty of Science and Marine Engineering, Hang Tuah University, Surabaya, Indonesia
Corresponding author: hanifardhio0202@gmail.com

Abstract

One of the keys to the success of ship repair is the supply chain (SC) process of materials that arrive on time. However, delays in its implementation were still found due to poor SC risk management. The purpose of the study is to identify risk factors for SC delay, measure risk factors and evaluate risk factors. This study uses the HOR (House of Risk) method which identifies risk variables (risk events and risk agents) and designs mitigation actions. The results of the HOR phase 1 study show an assessment score in the form of Aggregate Risk potential (ARP) which has a high influence on KM repair. Lintas Damai 1 includes: Supplier's unpreparedness in fulfilling orders with a score of 225, the forwarder experienced a delay in scoring 116 and Needs rejuvenation of facilities and transportation with a score of 120 and KM. Shinpo19 includes the quality of materials from suppliers that are of poor quality with a score of 280, materials that are difficult to obtain in the area with a score of 138 and the layout of poorly organized storage warehouses with a score of 92. The results of HOR phase II include mitigation actions to handle risk agents in KM. Lintas Damai 1 includes finding trusted supplier partners, increasing networking with other suppliers, holding tenders with suppliers who are ready and conducting service and checks every month. Meanwhile, KM. Shinpo19 has mitigation actions to handle risk agents, namely replacing materials with the same specifications but still of quality, having supplier connections with quality standards, supervising suppliers so that they comply with quality standards and structuring materials based on their type.

Keywords: House of risk; Risk management; Ship repair; Supply chain

1. Introduction

According to [1] SC is a network of industries that work together to produce and deliver products to customers. While [2] stated that the SC is a set of organizations that are directly connected through upstream and downstream values between processes that work collaboratively to reduce costs and waste. SC is a network of organizations and processes in which a number of companies collaborate along the entire value chain to source raw materials, to convert those raw materials into specific end products, and to deliver the final products to customers [3]. So, one of the keys to supporting the success of ship repair productivity is well-structured SC management so that the products we make are accepted by end users. According to [4] To be able to increase competitiveness against other shipyard competitors, several shipyards implement SC Management where one of the main factors of supply chain management success is the timely arrival of materials/components. However, during the activity, it is possible that there will be a risk of delay. Therefore, it is necessary to conduct an analysis and evaluation of SC risk management to reduce the impact of future losses. According to [5] one way to control and minimize the impact of risk is to implement risk management.

Currently, PT. XYZ is one of the ship repair companies that has not implemented SC risk management, so the risk factors that cause delays in material procurement have not been indicated. This raises several fatal loss problems, including: additional working time and even affects the shipyard's reputation. According to [6] One of the main causes of the hampered ship repair process is the procurement of materials to be used and the addition of ship repair activities. One of the cases of ship repair was hampered due to the procurement of materials at PT. XYZ is when the repair of the Lintas Damai 1 ship experienced a delay of 27 days and Shinpo 19 experienced a delay of 19 days. According to the company's director, the ship took the longest to carry out repairs with almost the same volume of work. This needs to be taken seriously because it can affect the ship's subsequent repairs.

To survive in a risky business environment, it is crucial for companies to have proper SC risk management in place [7]. However, according to [8] In the shipbuilding industry, there is still very little discussion of analysis regarding business risk management. While [9] revealed that disruptions to SC will be very risky in the course of a production process or other activities.

2. Method

The method used in this study is the HOR matrix method which is a combination of two methods, namely FMEA (Failure Mode Effect Analysis) and HOQ (House of Quality). According to [10] We modified the well-known FMEA model for risk quantification and adapted the HOQ model to prioritize which risk agents should be addressed first and to select the most effective actions to mitigate the potential risks posed by risk agents. The process of this research flow is based on the research flow diagram which is described as follows:

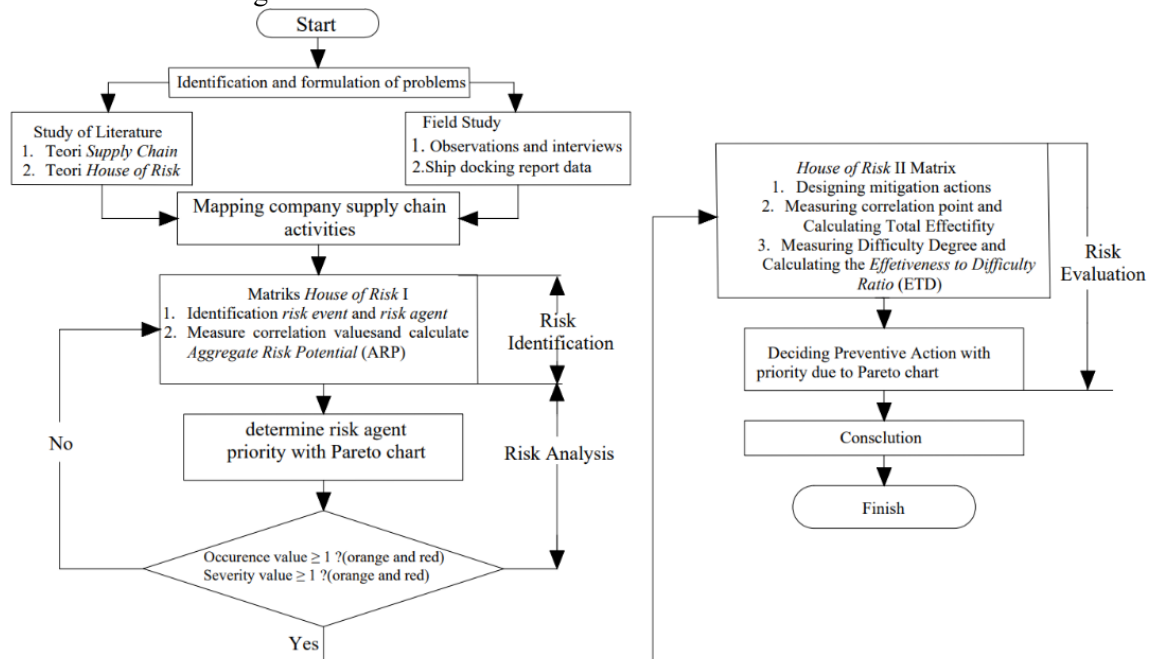


Figure 1. flowchart research.

- Problem Formulation

The problem that occurred in this study was the delay in the SC material process which resulted in the ship repair schedule. KM. Lintas Damai 1 and KM ships. Shinpo 19 became too late. From this problem, the formulation of the problem is to make risk mitigation to reduce the risk of SC material delays in the repair process using the HOR matrix method.

- Literature Studies

The literature study in this study is in the form of books, journals, and previous research which includes, the application of the HOR method in carrying out the stages of risk identification, risk analysis and risk evaluation.

- Field Studies

Field studies as data collection are in the form of interviews with shipyards, field observations, and questionnaires. So that risk factors for delays in procurement of goods in the company can be indicated.

- Research Design

- Identifying the risk of SC delays with the phase I HOR model
- Analyze risks by determining priority risk sources with pareto diagrams and risk mapping
- Evaluate the source of risk by making mitigation actions in HOR phase II

- Conclusion

Give answers to the formulation of problems that have been identified and provide suggestions and recommendations for the company and further research.

Pujawan and Geraldin developed the SC risk management model using the HOQ and FMEA methods to develop a framework for managing SC known as the HOR approach [11]. HOR has two stages, namely HOR phase I and HOR phase II. According to [12] HOR phase I is used to determine priority risk sources for mitigation actions and HOR phase II is used to provide mitigation actions to risk sources by considering the degree of difficulty in implementing them. The reason for this research is that the HOR matrix method is because this method is a renewable method from the old methods, namely the FMEA and HOQ methods. The difference between FMEA and HOQ methods is quite significant because the application is quite long and complicated for companies, in contrast to HOR, which is simple and easy to understand. According to [13] In FMEA, risk assessment can be calculated through the calculation of RPN (*Risk Potential Number*) obtained from the multiplication of three factors. According to [14] HOQ is not always easy to implement, and companies face problems in using HOQ, especially in large and complex systems. According to [15] stated that in the SC there are three flows that play an important role and must be managed properly, namely the flow of goods from upstream to downstream, the flow of money from downstream to upstream and the flow of information that flows both. According to [16] One attempt to measure the supply chain is to use the SCOR method. Meanwhile, according to [17] SCOR has five core processes, namely planning, procurement, production, delivery and return. According to [18] ISO 31000: 2018 is a risk implementation guide consisting of three elements, including principles, frameworks, and processes. According to [19] The HOR method has an advantage over other methods, namely having a *framework* that can analyze the entire process in risk management analysis, so that this framework is able to assist management in having priority risk agents based on the severity and at the same time the priority of mitigation actions. The disadvantages of the HOR method according to [20] is that this HOR method has a disadvantage, namely its application requires a lot of effort to define the desired business process.

3. Results and Discussion

3.1 Risk Identification

The results of mapping SC flow activities on KM ships. Lintas Damai 1 and KM. Shinpo 19 with the SCOR model consisting of the plan, source, manufacture and return process can be seen in table 1 and table 2. From the table, risk events are identified, and the level of impact severity is measured by the severity scale. The source of the severity scale assessment criteria is based on Pujawan, 2009 and brainstorming with resource persons where a value of one defines a delay of 1 day, a value of two defines a delay of 1.5 days, a value of three defines a delay of 2 days, a score of four defines a delay of 3.5 days and a score of five defines a delay of 4.5 days.

Table 1. Risk Event KM. Lintas Damai 1

Process	SC Flow Activity	Risk Event	Code	Severity
Plan	Production director receives material requirement request based on <i>repair list</i>	Coordination and communication failure with parties involved in the project	E1	4
	<i>Purchasing</i> planning with the purchasing division	Purchase order miscalculation	E2	3
		Fluctuations in material and component prices	E3	1
	<i>Supplier</i> selection process	Unavailability of materials from local <i>suppliers</i>	E4	3
		<i>Supplier</i> cannot fulfill the order	E5	4
Source	Material procurement process	Material delivery is not on time	E6	5
		Access to the project area is too difficult	E7	3
		Limited facilities	E8	2
		Material quantity from supplier is not suitable	E9	4

Process	SC Flow Activity	Risk Event	Code	Severity
Make	Checking of materials received / <i>quality control report</i>	Material quality from suppliers is defective	E10	5
	Material storage in warehouse	Materials and components damaged during storage	E11	2
	Production process	Late production schedule	E12	1
		Work accident	E13	1
		Material damage during use	E14	1
Return	Warranty claim for return of defective materials	Production machine malfunction	E15	2
		Material is damaged before the specified warranty time	E16	1

Table 1 shows the KM risk event . Lintas Damai 1 with the highest severity scale assessment at E6 "delivery of materials on time" and E10 "quality from suppliers is defective" with a value of five resulting in a delay of 4.5 days.

Table 2. Risk Event KM. Shinpo 19

Process	SC Flow Activity	Risk Event	Code	Severity
Plan	Production director receives material requirement request based on <i>repair list</i>	Material or component purchase request errors	E1	4
	<i>Purchasing</i> planning with the purchasing division	An error occurred in setting the self-estimated price	E2	3
		The procurement process is constrained due to funding	E3	1
	<i>Supplier</i> selection process	Materials not available from local <i>suppliers</i>	E4	3
Source	Material procurement process	Late delivery time of materials and components	E5	4
		Difficult access to the dockyard area	E6	3
	Checking of materials received / <i>quality control report</i>	Limited facilities	E7	1
		Material quality from <i>suppliers</i> is defective	E8	4
	Material storage in warehouse	Materials and components damaged during storage	E9	5
Make	Production process	Late in making production schedule	E10	2
		Material damaged during use	E11	1
		Production machine has problems	E12	1
Return	Warranty claim for return of defective materials	Material is damaged before the specified warranty time	E13	1

Table 2 shows the KM risk event. Shinpo19 with the highest severity scale rating on E9 "materials and components damaged during storage" with a value of five resulting in a delay of 4.5 days. After knowing the criteria for assessing severity, then conduct interviews and brainstorming to assess risk events with appropriate conditions in

the field. Based on table 1 of the risk event. There were 16 risk events in Lintas Damai I. Meanwhile, in table 2 of the risk event of KM. Shinpo 19 has 13 risk events during the repair process.

From these risk events, the source of risk will be identified to assess the probability of risk occurrence with a scale of occurrence. The source of the criteria for the occurrence assessment is based on Pujawan, 2009 and brainstorming with resource persons where the value of one indicates the probability of risk occurrence of 0-20%, the value of two indicates the probability of risk of 21%-40%, the value of three indicates the probability of risk of 41%-60%, the value of four indicates the probability of risk of 61%-80% and the value of five indicates the probability of risk of 81%-100%.

The results of the identification of the risk agent of the KM ship. Lintas Damai 1 can be seen in table 3 where there are 22 risk agents from 16 risk events. As for the risk agent of the KM ship. Shinpo 19 can be seen in table 4 which shows that there are 16 risk agents out of 13 risk events.

Table 3. Risk Agent Ship KM. Lintas Damai 1

Risk Event	Risk Agent	Code	Occurrence
Coordination and communication failure with parties involved in the project (E1)	Lack of <i>leadership</i> or ignorance in managing a project	A1	1
Purchase request calculation error (E2)	Material types and components are not clearly defined in the contract.	A2	1
Material and component price fluctuations (E3)	Currency exchange rates are volatile	A3	1
Unavailability of materials at local <i>suppliers</i> (E4)	Materials that are difficult to obtain in the area	A4	2
<i>Supplier</i> cannot fulfill the order (E5)	Incompleteness of <i>suppliers</i> used	A5	2
	Supplier unpreparedness in fulfilling orders	A6	5
	Late Issuance of <i>Purchase Order (PO)</i>	A7	3
Material delivery is not on time (E6)	Severe weather conditions	A8	1
	The forwarder was delayed	A9	2
	Long loading and unloading process	A10	1
	Waiting time at Customs	A11	1
Access to the project area is too difficult (E7)	Complicated area entry permit process	A12	1
Limited facilities (E8)	Need for rejuvenation of facilities and transportation	A13	5
	Limited budget for procurement of additional work tool inventory	A14	4
Material quantity from supplier is not suitable (E9)	The supplier's mistake was a miss communication	A15	2
Material quality from suppliers is defective (E10)	Poor quality materials from <i>suppliers</i>	A16	2
Materials and components damaged during storage (E11)	Unorganized storage warehouse layout	A17	2
Late production schedule (E12)	Short working hours result in not being realized immediately.	A18	3

Risk Event	Risk Agent	Code	Occurrence
Work accident (E13)	Workers do not wear PPE	A19	2
Material damage during use (E14)	Worker error when using materials	A20	2
Production machine malfunction (E15)	Lack of routine maintenance	A21	1
Material is damaged before the specified warranty time (E16)	Internal damage to components or materials	A22	1

Table 3 shows the risk agent KM. Lintas Damai 1 with the highest occurrence scale assessment at A6 "supplier unpreparedness in fulfilling orders" and A13 "Need for rejuvenation of facilities and transportation" with a value of five defines the probability of risk occurring 81%-100%.

Table 4. Risk Agent Ship KM. Shinpo 19

Risk Event	Risk Agent	Code	Occurrence
Material or component purchase request error (E1)	Agreed contract does not fully describe materials and components	A1	1
Error in setting own estimate price (E2)	Price information on the market is still not available	A2	1
The procurement process is constrained due to funding (E3)	Discrepancies between budget plans and conditions in the field	A3	2
Material not available from local <i>suppliers</i> (E4)	Materials that are difficult to obtain in the area	A4	3
Late delivery of materials and components (E5)	Late Issuance of PO	A5	1
	The forwarder was delayed	A6	2
	Waiting time at Customs	A7	1
Difficult access to the shipyard area (E6)	Complicated area entry permit process	A8	1
Limited facilities (E7)	Need for rejuvenation of facilities and transportation	A9	4
	Limited budget for procurement of additional work tool inventory	A10	4
The quality of materials from suppliers is defective (E8)	Poor quality materials from <i>suppliers</i>	A11	5
Materials and components damaged during storage (E9)	Unorganized storage warehouse layout	A12	2
Late in making production schedule (E10)	Short working hours result in not being realized immediately.	A13	1
Material is damaged during use (E11)	Worker error when using materials	A14	2
Production machine has problems (E12)	Lack of routine maintenance	A15	2
Material is damaged before the specified warranty time (E13)	Internal damage to components or materials	A16	1

Table 4 shows the risk agent KM. Shinpo 19 with the highest occurrence scale assessment on A11 "poor quality materials from suppliers" with a value of five defines the probability of risk occurring 81%-100%. After the identification of risk events and the identification of risk agents are fulfilled, the next step is to create a phase I HOR table which contains measuring the correlation between risk agents and risk events on the two ships and calculating the ARP value based on the correlation that has been filled in by the resource person. The ARP equation is:

$$ARP = O_j \times \sum Si \times Rij \quad (1)$$

Information:

ARP_j : Aggregate Risk Potential

O_j : Probability of risk occurrence (occurrence)

Si : Impact of the severity of the risk event (severity)

R_{ij} : Correlation value between risk agents and risk events

The correlation assessment criteria have been determined by Pujawan and Geraldin, namely the assessment criteria 0,1,3 and 9. The number 0 defines no relationship between risk agents and risk events, the number 1 indicates that there is a weak relationship between risk agents and risk events, the number 3 defines a moderate relationship between risk agents and risk events and the number 9 indicates that there is a strong relationship between risk agents and risk events.

Table 5. Matrix HOR Phase I KM. Lintas Damai I

Risk Event (Ei)	Risk Agent (Aj)																						Si
	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	
E1	9	3					3																4
E2	3	9					3																3
E3			9			9																	1
E4				3	9				3		3					1							3
E5				3	3	9	1																4
E6	1	1	1	1	1		9	3	9	3	3				1								5
E7												9											3
E8	3												9	3			3		3		1	1	2
E9		3													3								4
E10					3											3				3		9	5
E11							3	1					3	3		3	3						2
E12	9								3		1							3					1
E13																			9	1	3		1
E14								3						1		9				3		3	1
E15														1							3		2
E16																3				1		9	1
O _j	1	1	1	2	2	5	3	1	2	1	1	1	5	4	2	2	2	3	2	2	1	1	
ARP	65	61	14	52	118	225	228	20	116	15	25	27	120	60	34	210	24	9	30	40	11	77	
Rank	8	9	20	11	5	2	1	18	6	19	16	15	4	10	13	3	17	22	14	12	21	7	

For example, the medium correlation value in table 5 occurs in the risk agent code A4 (Materials that are difficult to obtain in the area) with the risk event E5 (Supplier cannot fulfill the order) with the meaning that the two codes have a relationship with the medium level which has a value of 3. HOR table of phase I of KM ships. Lintas Damai 1 has the highest ARP value on risk agent A7, namely the issuance of late purchasing orders with a value of 228.

Table 6. Matrix HOR Phase I KM. Shinpo 19

Risk Event (Ei)	Risk Agent (Aj)																Si
	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	
E1		3															4
E2		3	9	9													3
E3		1	3	9	1	3			1	1							1
E4					3	9	3				1						3
E5					9	9	3	9	3								4
E6						3		9									3

Risk Event (Ei)	Risk Agent (Aj)																Si
	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	
E7									9	9						1	1
E8											9					3	4
E9									3	1	1	9				3	5
E10						3	3						1				2
E11											9	1		3		3	1
E12									9	9					9	3	1
E13										1	3			3		9	1
Oj	1	1	2	3	1	2	1	1	4	4	5	2	1	2	2	1	
ARP	22	30	72	138	66	54	51	39	136	100	280	92	2	12	18	43	
Rank	13	12	6	2	7	8	9	11	3	4	1	5	16	15	14	10	

For example, the strongest value in table 6 occurs in the risk agent code A2 (Price information in the market is still not available) and risk event E2 (An error in setting the estimated price by yourself). In the sense that the two codes have a strong relationship, there is a risk arising. HOR table of phase I of KM ships. Shinpo 19 is shown in table 6 with the highest ARP value on risk agent A11, namely the quality of materials from suppliers that are of poor quality with a value of 280.

3.2 Risk Analysis

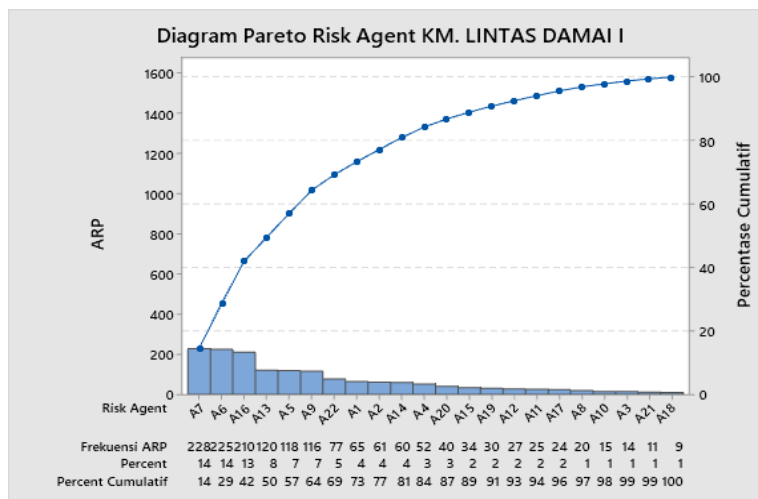


Figure 2. Pareto Chart of KM ship. Lintas Damai 1

Further handling actions are needed to manage risk agents on the two ships, therefore each risk agent on the KM ship. Lintas Damai and KM ships. Shinpo 19 needs to be given mitigation action. Each risk agent can be handled with more than one mitigation action. It should be noted that mitigation actions should be as relevant as possible to risk agents so that they can reduce the source of risk appropriately. Therefore, it is necessary to conduct an interview process with resource people.

Before designing mitigation actions, the stage after HOR phase I is to create a pareto diagram based on the ARP ranking from highest to lowest. The purpose of making a pareto diagram is to analyze priority risk agents to make mitigation actions, in accordance with the pareto concept, which is 80/20 that is risk agents with a cumulative percentage of 0-80% will be taken as priority risk agents. Chart of the KM ship. Lintas Damai 1 is shown in figure 1 and figure 2 for the KM ship pareto chart. Shinpo 19.

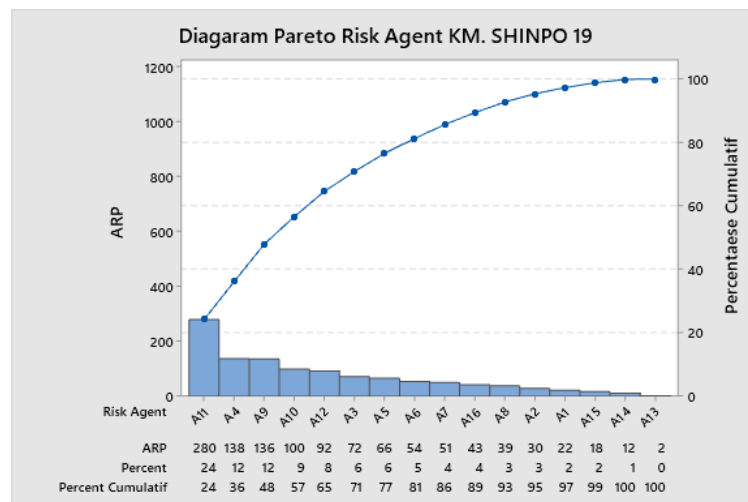


Figure 3. Pareto Chart of KM ship. Shinpo 19

From the pareto chart of the KM ship. Lintas Damai 1 is known to get priority risk agents are A7, A6, A16, A13, A5, A9, A22, A1 and A2. As for the pareto diagram of the KM ship. Shinpo 19 received seven priority risk agents with risk agent codes, namely A11, A4, A9, A10, A12, A3 and A5.

If you have obtained priority risk agents on the two ships, to find out the risk agents that must be acted on first, a risk mapping is made in the form of risk mapping which aims to find out the risk agents that need to be given immediate action or simply given action according to applicable procedures.

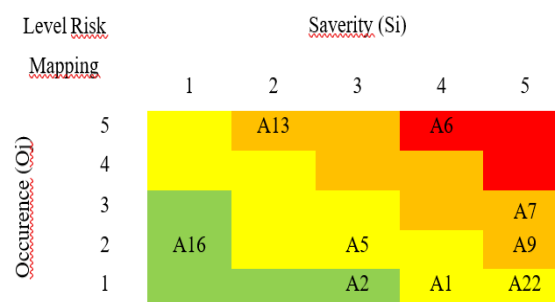


Figure 4. Risk Mapping KM. Lintas Damai I

Figure 4 is the risk mapping of the KM ship. Lintas Damai 1 shows that the risk agent with codes A16 and A2 is located in green which means that action is needed according to the procedure, while for risk agents A5, A22 and A1 it is located in yellow which means that action is carried out periodically, then for risk agents A13, A7 and A9 it is located in orange with the intention of being given immediate action, while risk agent A6 is located in red which means that action must be given directly.

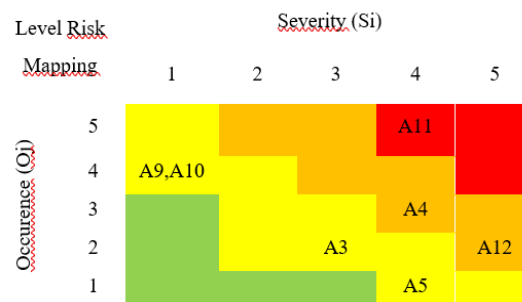


Figure 5. Risk Mapping KM. Shinpo 19

On the risk mapping of KM ships. Shinpo 19 shows that risk agents A9, A10, A3, and A5 are located in yellow which means they are given action periodically, for risk agents A12 and A4 are located in orange which means immediate action is taken, while risk agent A11 is located in red which means immediate action is taken. From the orange and red risk agents, they are taken as selected priority risk agents which will be the input to HOR phase II, for example on the KM Lintas Damai 1 ship there are selected risk agents with orange colors, namely A9 (The forwarder is delayed), A13 (Needs rejuvenation of facilities and transportation) and red A6 (Supplier's unpreparedness in fulfilling orders).

3.3 Risk Evaluation

In HOR phase II, the first step is to design mitigation actions from selected priority risk agents. The mitigation action of the KM. Lintas Damai 1 can be seen in table 7 while the mitigation action of KM. Shinpo 19 is shown in the table 8.

Table 7. Mitigation Actions KM. Lintas Damai I

Selected Priority Risk Agents	Preventive Actions	Code
Supplier unpreparedness in fulfilling orders (A6)	Increase <i>networking</i> with <i>other</i> suppliers	PA1
	Hold a tender with suppliers who are ready	PA2
	Find a <i>trusted</i> supplier partner	PA3
Need to rejuvenate facilities and transportation (A13)	Perform service and check every month	PA4
Late PO issuance (A7)	Replacing new facilities and transportation that are not guaranteed	PA5
	Create a planning and schedule for the issuance of PO in the purchasing division so that they can be made immediately	PA6
The forwarder experienced delays (A9)	Replacing a forwarder with a trusted delivery	PA7
	Transfer the risk of delay with a third party or insurance party	PA8

Table 8. Mitigation Action KM. Shinpo 19

Selected Priority Risk Agents	Preventive Actions	Code
Material quality from <i>poor quality</i> suppliers (A11)	Conduct supervision and monitoring of <i>suppliers</i> to ensure they comply with the quality and safety standards that have been implemented	PA1
	Have supplier connections that have quality standards	PA2
Materials that are difficult to obtain in the area (A4)	Expanding <i>the network of suppliers</i> outside the city and abroad	PA3
	Make stock of materials that are difficult to get so that you don't have trouble finding them during future repairs	PA4
	Replacing materials with the same specifications but the quality can still be tolerated	PA5
Poorly organized storage warehouse layout (A12)	Creating a neat and organized warehouse lay out	PA6
	Structuring materials by dividing them by their types	PA7
	Renovate the warehouse by expanding it	PA8

After designing several mitigation actions to deal with risk agents, the next step is to conduct a correlation assessment between mitigation actions and preferred priority risk agents obtained from interviews with respondents. The correlation assessment criteria have been determined by Pujawan and Geraldin. This correlation assessment is the same as the correlation assessment in HOR phase II which uses assessment criteria 0,1,3 and 9. If the correlation value has been measured, the Totak Efektivnest (Te) calculation is carried out from the mitigation action design. Based on the HOR method, it is to identify the value of how important the mitigation action is applied. TE can be described in the following equation:

$$TE_k = \sum ARP_j \cdot E_{jk} \quad (2)$$

Information:

Tek : Total Effectiveness

ARPj : Aggregate Risk Potential

Ejk : Correlation between mitigation actions and risk agents

The next stage is to assess the degree of difficulty of each mitigation action. Assessing the degree of difficulty (Dk) of mitigation actions is carried out to find out how great the degree of difficulty is if the mitigation action is implemented. This assessment was carried out by interviews and brainstorming with the respondents. The criteria for the degree of difficulty scale are based on Pujawan, 2009, which is on a scale of 3 which describes that mitigation actions are easy to implement. Scale 4 describes that mitigation actions are sufficient to be implemented. A scale of 5 indicates that mitigation actions are difficult to implement in the field.

After getting the Dk score, the next step is to measure the Effectiveness to Difficulty Ratio (ETD). The ETD assessment is used to determine the priority ranking based on the results of the ETD calculation from the highest to the lowest value. The value of this ratio is obtained from the division of total effectiveness (TEk) by the degree of difficulty (Dk). The ETD value formula can be seen as follows:

$$ETD = TEk / Dk \quad (3)$$

Information:

ETD = Effectiveness and difficulty ratio

TEk = Total effectiveness of each action

Dk = Degree of Difficulty

The following is the HOR phase II matrix of the KM ship. The Peace I Trail is shown in table 9 and KM. Shinpo 19 shown in table 10.

Table 9. Matrix HOR Phase II KM. Lintas Damai I

Risk Agent	Preventive Action (PA)								ARP
	PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8	
A6	9	9	9	1					225
A13	1		3	9	9	3			120
A7						9			228
A9							3	9	116
TEk	2145	2025	2385	1305	1080	597	348	1044	
Dk	3	4	3	3	5	4	3	3	
ETD	715	506	795	435	216	149	116	348	
Ranking	2	3	1	4	6	7	8	5	

Based on table 9, the total calculation of the effectiveness of KM. Lintas Damai 1 shows the highest TE in PA 3 mitigation action, namely looking for trusted supplier partners with a TE value of 2385. Meanwhile, the degree of difficulty of mitigation action of KM ships. The Damai I Cross which has the highest score on PA 5 is replacing new facilities and transportation that are less guaranteed with a value of Dk 5. ETD value KM. Lintas Damai I obtained the highest ETD value in PA 3, namely looking for trusted supplier partners with an ETD value of 795.

Table 10. Matrix HOR Phase II KM. Shinpo 19

Risk Agent	Preventive Action (PA)								ARP
	PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8	
A11	9	9	1		9				280
A4		1	9	9	9	1	9		138
A12						9	9	9	92
TEk	2520	2658	1522	1242	3762	966	2070	828	
Dk	3	3	3	5	4	3	3	4	
ETD	840	886	507	248	941	322	690	207	
Ranking	3	2	5	7	1	6	4	8	

Table 10 KM. Shinpo 19 shows the highest TE value in the PA code 5 mitigation action, namely replacing materials with the same specifications but the quality is still tolerable with a value of 3762. Meanwhile, the KM. Shinpo 19 which has the highest degree of difficulty in PA 4 is to make stock materials that are difficult to get so that it is not difficult to find during future repairs with a value of Dk 5. The KM. Shinpo 19 obtained the highest ETD value in PA 5, which is replacing materials with the same specifications but the quality is still tolerable.

The last step in HOR phase II is to create a pareto diagram to find priority mitigation actions. Diagram of ETD of KM ships. Lintas Damai 1 is shown in figure 6 and the diagram of the ETD pareto of the KM ship. Shinpo 19 is shown in figure 7.

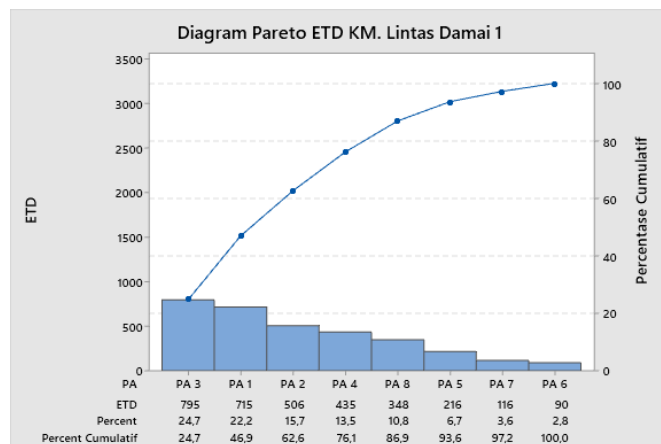


Figure 6. Pareto Chart ETD KM. Lintas Damai 1

Based on the ETD KM pareto diagram. Lintas Damai 1 is taken as a cumulative percentage of up to 80% and 4 priority mitigation actions are obtained, including PA 3, which is looking for trusted supplier partners, PA 1, which is increasing networking with other suppliers, PA 2, which is holding tenders with suppliers who are ready, and PA 4, which is conducting service and checking every month.

The results of the ETD KM pareto chart. Shinpo 19 in figure 7 obtained 4 mitigation actions, including PA 5, which is replacing materials with the same specifications but the quality is still tolerable, PA 2, which has supplier connections that have quality standards, PA I, which is supervising and monitoring suppliers to ensure they comply with the quality and safety standards that have been implemented, and PA 7, which is structuring materials by dividing them based on their types.

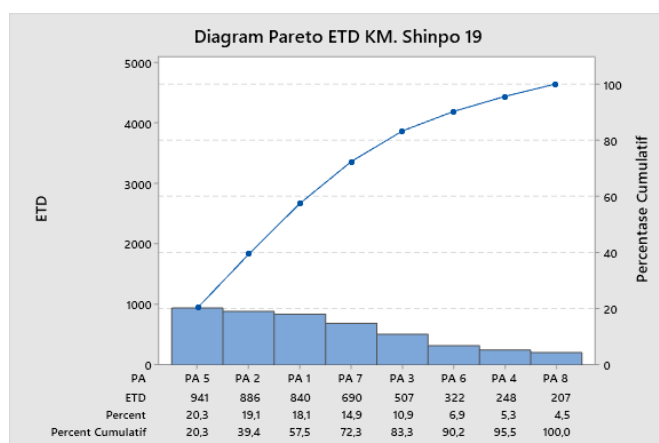


Figure 7. Pareto Chart ETD KM. Shinpo 19

The difference between this study and the previous study is that this study uses risk mapping which is guided by ISO 31000:2018 risk management before carrying out risk mitigation actions. With this, it can be known which risks have an extreme level that must be acted upon directly or only a low level that must be acted upon periodically.

4. Conclusions

Based on the results of the research from the HOR I matrix table, there are 4 most dominant risk factors on KM ships. Lintas Damai I is the issuance of a late purchase order with an ARP value of 228, the unpreparedness of suppliers in fulfilling orders with an ARP value of 225, the need for rejuvenation of facilities to transportation with an ARP value of 120 and the forwarder experienced delays with an ARP value of 116. Meanwhile, KM. Shinpo 19 has 3 most dominant risk factors including the quality of materials from suppliers with an ARP value of 280, materials that are difficult to obtain in the area with an ARP value of 138 and a poorly maintained storage warehouse layout with an ARP value of 92. From the factors that cause these risks, priority mitigation actions are designed to reduce further risks. KM mitigation action. Lintas Damai I includes finding trusted supplier partners, increasing networking with other suppliers, holding tenders with suppliers who are ready and conducting services and checks every month. Meanwhile, the mitigation action of KM. Shinpo 19 has 4 mitigation actions, namely replacing materials with the same specifications but the quality can still be tolerated, having supplier connections that have quality standards, supervising and monitoring suppliers to ensure they comply with safety standards and structuring materials by dividing them by type.

There is an impact on this research, namely KM. Lintas Damai 1 before the mitigation action was planned which experienced a delay of 27 days with after the mitigation action was planned was reduced to 11.5 days. As for KM. Shinpo 19 has a comparison before the mitigation action was planned to experience a delay of 19 days with after the mitigation action was planned it was reduced to 9 days.

Acknowledgment

The author would like to thank the supervisor who has helped in this writing and the shipyard of PT. Tambangan Raya Permai.

References

- [1] I. Baroroh, I. M. Ariana, and A. A. B. Dinariyana, "Supply chain performance analysis on modular construction shipbuilding," in *IOP Conference Series: Earth and Environmental Science*, IOP Publishing Ltd, Sep. 2020.
- [2] J. Reyes, J. Mula, and M. Díaz-Madroñero, "Development of a conceptual model for lean supply chain planning in industry 4.0: multidimensional analysis for operations management," *Production Planning and Control*, vol. 34, no. 12, pp. 1209–1224, 2023,
- [3] D. Ivanov, S. Sethi, A. Dolgui, and B. Sokolov, "A survey on control theory applications to operational systems, supply chain management, and Industry 4.0," *Annu Rev Control*, vol. 46, pp. 134–147, Jan. 2018,
- [4] H. Alrosyid and R. Prabowo, "Seminar Nasional Hasil Penelitian dan Pengabdian kepada Masyarakat Unipma Optimasi Proses Impor Komponen Kapal Pada Supply Chain Management Menggunakan Montecarlo," 2019.
- [5] I. Baroroh, I. M. Ariana, and A. A. B. Dinariyana, "Risk Analysis of Engine Room Module Installation with Integration of Bayesian Network and System Dynamics," *International Review of Mechanical Engineering (IREME)*, vol. 16, no. 6, p. 299, Jun. 2022,
- [6] I. Baroroh, G. V. Setiawan, A. Azhar, D. Hardianto, and A. B. Widodo, "Risk Analysis of Delay in Ship Repair KM Binaiya with Bayesian Network Method," *International Journal of Marine Engineering Innovation and Research*, vol. 8, no. 3, pp. 2548–1479, Sep. 2023.
- [7] I. N. Pujawan and L. H. Geraldin, "House of risk: A model for proactive supply chain risk management," *Business Process Management Journal*, vol. 15, no. 6, pp. 953–967, Nov. 2009,

- [8] Z. D. Cahyani, S. R. W. Pribadi, and I. Baihaqi, "Studi Implementasi Model House of Risk (HOR) untuk Mitigasi Risiko Keterlambatan Material dan Komponen Impor pada Pembangunan Kapal Baru," *Jurnal Teknik ITS*, vol. 5, no. 2, pp. 52–59, 2016.
- [9] R. Andrias Sahulata, E. Gumabo, J. A. Mononutu, A.-M. Utara, and S. Utara, "Analisis Manajemen Risiko Supply Chain Menggunakan Metode House of Risk pada PT. Bandar Trisula," 2023.
- [10] I. N. Pujawan and L. H. Geraldin, "House of risk: A model for proactive supply chain risk management," *Business Process Management Journal*, vol. 15, no. 6, pp. 953–967, Nov. 2009,
- [11] Y. E. Pertiwi and A. Susanty, "Analisis Strategi Mitigasi Resiko Pada Supply Chain Cv Surya Cip Dengan House of Risk Model," 2017.
- [12] M. E. Sibuea¹, D. Hadi, and S. Saragi¹, "Analisis Risiko Keterlambatan Material dan Komponen pada Proyek Pembangunan Kapal dengan Metode House of Risk (HOR) Studi Kasus: Pembangunan Kapal Ro-Ro 300 GT Danau Toba," *Jurnal Sistem Teknik Industri (JSTI)*, vol. 21, no. 2, pp. 28–42, 2019.
- [13] D. Lintang Trenggonowati and N. Atmi Pertiwi, "Analisis Penyebab Risiko Dan Mitigasi Risiko Dengan Menggunakan Metode House of Risk Pada Divisi Pengadaan PT XYZ," *Journal Industrial Servicess*, vol. 3, no. 1a, 2017.
- [14] E. S. Jaiswal, "A Case Study on Quality Function Deployment (QFD)," *IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)*, vol. 3, no. 6, pp. 27–35, 2012, [Online]. Available: www.iosrjournals.org
- [15] F. Ayu Astuti and T. Siahaan, "Manajemen Rantai Pasok Dalam Pembangunan Kapal Angkut Tank Guna Meningkatkan Daya Saing Industri Pertahanan Matra Laut (Studi Pt Daya Radar Utama) Supply Chain Management in The Building of Leading Ship Tank to Increase Competitive Advantage In Shipyard Defense Industry (Studied PT DAYA RADAR UTAMA)," *Jurnal Industri Pertahanan*, vol. 1, no. 2, pp. 59–86, 2020, [Online]. Available: <http://maritimnews.com/visi-poros-maritim-dunia-dan-konsepsi-wawasan-nusantara/>,
- [16] P. Ricardianto *et al.*, "Supply chain management evaluation in the oil and industry natural gas using SCOR model," *Uncertain Supply Chain Management*, vol. 10, no. 3, pp. 797–806, 2022,
- [17] R. A. Puspita, A. Sykahroni, and N. Khoiriyah, "Pengukuran Kinerja Rantai Pasok Menggunakan Metode Supply Chain Operation Reference (SCOR) Dan Fuzzy Analytical Hierarchy Process (F-AHP)," *Jurnal Teknik Industri (JURTI)*, vol. 1, no. 2, pp. 120–127, 2022.
- [18] K. Bima Mahardika *et al.*, "Manajemen Risiko Teknologi Informasi Menggunakan ISO 31000 : 2018 (STUDI KASUS: CV. XY)," *Sebatik*, vol. 23, no. 1, pp. 277–284, 2019.
- [19] R. Purwaningsih and F. A. Akhsan, "Analisis Strategi Mitigasi Risiko Cacat Part Hopper Menggunakan Metode House of Risk Di Pt Cahaya Maju Bahagia," *Industrial Engineering Online Journal*, 2023.
- [20] M. Ulfah, M. Syamsul Maarif, and S. Raharja, "Analisis Dan Perbaikan Manajemen Risiko Rantai Pasok Gula Rafinasi Dengan Pendekatan House of Risk Analysis and Improvement of Supply Chain Risk Management Of Refined Sugar Using House of Risk Approach," *Jurnal Teknik Industri Pertanian*, vol. 26, no. 1, pp. 87–103.