RISK MITIGATION OF DAMAGE TO ELECTRONIC INTEGRATED CIRCUIT (IC) PRODUCTS DURING SHIPPING USING THE HOUSE OF RISK METHOD (HOR)

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Abstract. PT XYZ is a semiconductor company that produces many automotive products. Various products that have passed the assembly and testing process will then be sent to distribution centers in Asia and Europe. In company activities there are risks that are important to manage in order to smooth the flow of the company. In the process of shipping products, there is a risk of defects that trigger the return of goods to the company. Based on the company's IMC (Internal Management Complaint) data, the most common item damage is damaged product boxes (pallet boxes) that require corrective action. To minimize this risk, risk management is needed using the House Of Risk (HOR) method which aims to analyze and mitigate the risk of damage to goods in the process of shipping goods at PT XYZ. The HOR method identifies 21 risk events and 23 risk agents that have the potential to cause damage to goods. Based on the calculation of Aggregate Risk Potential (ARP), 5 risk agents are prioritized for handling. There are 12 handling strategies proposed to be able to reduce the possibility of risk agents in the company's goods delivery.

Keywords: Packaging, Delivery Of Goods, House Of Risk.

1 Introduction

Shipping goods is one of the most critical activities in the business sector. Goods shipping enables companies to easily send their products to customers in various locations, expand their market reach, and support global supply chains [1].

PT XYZ, a renowned global semiconductor manufacturer, is one of the companies involved in the shipment of goods. Headquartered in Germany and operating in Batam, the company has developed a range of products catering to the automotive industry. These products are typically utilized as primary components in the fabrication of Integrated Circuits, which play a crucial role in information processing. This research undertakes an in-depth analysis of the pre-shipment goods handling process, specifically within the shipping section of PT XYZ. The study identifies and examines the operational challenges faced by the shipping section, including the potential for

damage to goods or packaging, which can lead to goods being rejected by the Distribution Center (DC) or deemed defective.

The shipping process typically entails the preparation and physical transfer of goods from the warehouse to their intended destination, in compliance with order documentation and goods handling requirements. The overarching goal of shipping is to ensure the rapid and secure delivery of goods to their destination. Shipping constitutes a key activity that involves the delivery of goods as a result of merchandise sales. These sales can encompass the sale of goods or services, which may be facilitated through either cash or credit transactions[2]. a product refers to "any offering that can be presented to a market to satisfy consumer needs and wants". Quality control is a vital process that enables companies to guarantee that their products conform to established standards and meet the requirements of their target market. To achieve sustained success, businesses must prioritize product quality. By implementing effective quality control measures, companies can prevent product defects or failures, thereby reducing losses and enhancing customer satisfaction[3].

Risk refers to an adverse event that introduces uncertainty about its occurrence within a specific timeframe, resulting in losses that can range from minor to significant and potentially impacting business operations[3]. Risk identification is a critical component of risk management that provides a systematic approach to identifying how individual or organizational objectives can be influenced by risk [4]. The risk identification process seeks to identify and understand various potential unwanted outcomes, unexpected results, emerging threats, and existing and potential opportunities. The ultimate output of risk identification is a comprehensive risk register that comprises two essential components: risk statements and risk causes. Following the successful compilation of the risk register, the next step is to conduct risk measurement.

Implementing risk control measures is crucial for companies to prevent accidents and minimize losses. By assessing the frequency and impact of potential risks, companies can gain a more comprehensive understanding of the severity of the risks they face, which serves as a foundation for developing effective risk control strategies. The benefits of this approach include identifying employees who are most susceptible to risks, understanding the factors that can be mitigated or eliminated, and developing a deeper awareness of the mitigation methods that need to be employed. This heightened awareness enables companies to be more proactive and informed in their approach to risk management, ultimately allowing them to implement the most appropriate mitigation strategies. Risk mitigation is a proactive risk response strategy that involves the project team taking deliberate actions to reduce the likelihood or impact of a potential risk.

2 House Of Risk Model

The House Of Risk (HOR) method is a methodology developed by Pujawan & Geraldin (2009) that combines two popular approaches, namely Failure Mode and Effect Analysis (FMEA) and Quality Function Deployment (QFD). This method is designed

to identify and address problems (risks) that arise in the supply chain. The main advantage of the HOR method lies in its strategic proactive framework, which enables companies to anticipate and minimize risks before they have a negative impact on business operations.

The Failure Mode and Effect Analysis (FMEA) method is a proactive risk assessment method widely used in industry. Failure Mode refers to the failure of a product or process to perform its intended function or the cause of failure, while effect analysis involves analysing the potential consequences of each failure [5]. Risk assessment is performed by calculating the Risk Potential Number (RPN), which is obtained by multiplying three factors: severity, occurrence, and detection. This can be formulated as follows:

$$ARPj = Oj \Sigma Si R$$

The Quality Function Deployment (QFD) methodology is a quality enhancement approach that aims to determine the most effective strategies. As defined by Hairiyah (2021), the QFD concept is a systematic method that can be employed in product planning and development to identify and specify consumer needs, and to evaluate products or services in a structured manner that aligns with consumer requirements.

The House of Risk (HOR) methodology provides a holistic approach to risk analysis and mitigation across diverse business processes. By employing the HOR method, organizations can identify and assess all potential risks, prioritize the most critical ones by understanding their underlying causes (risk agents), and select mitigation strategies based on their effectiveness and feasibility. This approach ensures that the chosen solutions deliver optimal value. The HOR method places particular emphasis on addressing risk agents with high Aggregate Risk Potentials (ARP) values. The House of Risk (HOR) methodology is comprised of two distinct stages[6]:

2.1 HOR Phase 1: Risk Agent Prioritization

The initial phase of the House of Risk methodology entails a comprehensive process of identifying and analyzing risk events, as well as their underlying causes. This phase involves evaluating the severity of risk events, determining the occurrence probability of risk causes, and assessing the correlation between risk events and their corresponding causes.

Table 1. Severity & Occurance

Severity	Level	Occurance	Level
No	1	Almost never	1
Very slight	2	Remote	2
slight	3	Very slight	3
Minor	4	Slight	4
Moderate	5	Low	5

Severity	Level	Occurance	Level
Significant	6	Medium	6
Major	7	Moderately high	7
Extreme	8	High	8
Serious	9	Very high	9
Hazardous	10	Almost certain	10

This phase is designed to identify the risk agents that require immediate attention. The following steps are necessary to achieve this[7]:

1. Identify business processes or supply chain activities that are susceptible to risk.
2. Determine the risk events (Ei) that can occur in each business process.
3. Assess the potential impact of each risk event and evaluate its severity (Si).
4. Identify the risk agents responsible for each risk event and evaluate their probability of occurrence (Oj).
5. Establish the correlation between each risk event and its corresponding risk agent, using a scale of 0 to 9, where: 0 indicates no correlation, 1 indicates a low correlation, and 3 indicates a moderate correlation 9 indicates a high correlation
6. Calculate the Aggregate Risk Potential (ARPj) of each risk agent, which represents the total potential risk associated with that agent.
7. Rank the risk sources in order of their potential risk, from highest to lowest, to prioritize mitigation efforts.

2.2 HOR Phase 2: Prioritizing Effective Risk Management Strategies

This phase involves prioritizing risk management strategies based on their financial viability and resource availability. The primary objective of this phase is to determine the most critical actions that need to be taken first. The implementation of HOR Phase 2 involves the following steps [7]:

1. Select a subset of high-priority risk agents using Pareto analysis of their Aggregate Risk Potential (ARPj) values.
2. Identify relevant actions (PAk) that can be taken to prevent or mitigate each risk agent. It is possible that multiple actions may be required to address a single risk agent, and that a single action may be effective in mitigating multiple risk agents.
3. Determine the correlation between each risk agent and each preventive action, using a correlation value scale of 0 to 9.
4. Calculate the total effectiveness (TEk) of each action, which is the sum of the product of the ARPj values and the correlation values (Ejk) for each risk agent. Which is

$$TEk = \Sigma ARPj\ Ejk$$

5. Assessing the degree of difficulty (Dk) associated with implementing each corrective action k to mitigate risk. The degree of difficulty is categorized into three levels: 3 (Low), indicating ease of implementation 4 (Medium), indicating moderate difficulty in implementation 5 (High), indicating significant difficulty in implementation
6. Calculating the total effectiveness-difficulty ratio (ETDk) using the formula:

$$ETDk = TEk/Dk.$$

7. Developing a priority ranking by assigning a rank to each action based on its ETDk value, where the action with the highest ETDk value is assigned rank 1, indicating that it is the most feasible to implement.

3 Case

This research is centered on examining the pre-shipment goods handling process, which is the responsibility of the shipping section at PT XYZ. The study undertakes an in-depth analysis of the operational challenges faced by the shipping section. The issues plaguing the shipping section at PT XYZ are evident in the potential for damage to goods or packaging, leading to goods being rejected by the distribution center or deemed defective.

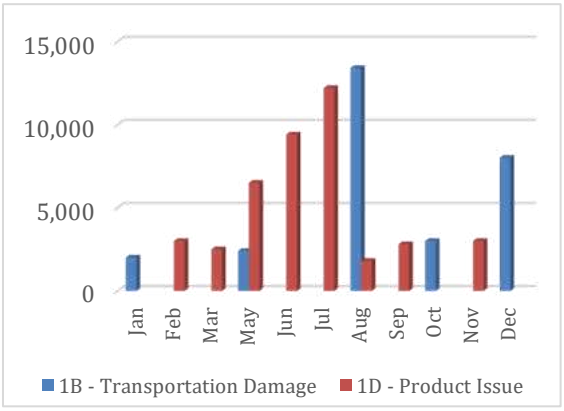

Fig. 1. IMC Report for Product Damage

Figure 1. presents the data on product damage based on the Internal Management Complaint (IMC) records of PT XYZ from January 2023 to December 2023. Despite the successful completion of the shipping process and the arrival of goods at the Distribution Central warehouse, it was discovered that the products were in a compromised state, either due to damage to the pallet box or inner box, prompting the Distribution Central to quarantine the products deemed unfit for distribution to customers. As revealed in the initial interview with the shipping supervisor, if damage is detected on the pallet box but the products within the inner box remain intact, the

Distribution Central will undertake re-packaging efforts. Conversely, if damage to the pallet box also affects the products inside, a formal complaint and return request will be submitted for the defective products.

A return refers to the process of returning a product due to various reasons, including product damage or errors. This inevitably has significant implications for PT XYZ, both in terms of financial costs and the trust of stakeholders [8]. Consequently, it is essential to take corrective measures to mitigate the damage and prevent losses for the company. The application of the House of Risk (HOR) method can be employed to address the emerging issues. The HOR model provides a foundational framework for risk management, emphasizing the identification, prevention, and mitigation of potential risk factors.

4 Result Analysis

The initial phase of the House of Risk methodology involved a comprehensive risk identification process, wherein risk events and their underlying causes were systematically identified and documented. Based on the data gathered, a comprehensive analysis was conducted on the goods handling process prior to shipment at the shipping store area of PT XYZ's Logistics Department, Shipping Section. The analysis was performed on the data collected and processed, and the results are presented as follows:

4.1 Identification of Goods Handling Activities

Preliminary to the identification of risk events and risk agents, the initial step involved the mapping of goods handling activities undertaken in the shipping area, which are outlined as follows:

Table 2. Activities at the shipping store

Goods packaging activities
Receiving lot from production.
Receiving lot at SAP
Sorting physical and segregate based on DC.
Scanning lot at assist system
Stuffing Finishgoods to pallet box.
Goods shipping activities
Stacking pallet
Document prepare
Driver check
Security check
Loading kontainer
Documentation

4.2 Identification of risk events and assessment of their severity

Risk Events (Ei) refer to all potential occurrences that may arise during the shipping process, from receipt to dispatch, which can result in losses to the company and can be quantified using a severity impact scale. To gather information on these risk events, a comprehensive documentation of complaints from the Distribution Center (DC) related to goods was conducted, supplemented by in-depth interviews with key informants. Furthermore, a literature review was undertaken to establish a severity assessment framework based on the correlation between severity and the IMC report.

4.3 Identification of risk events and assessment of their severity

Risk Agents refer to the factors that contribute to the occurrence of each risk event. It is possible for a single risk event to be triggered by one or more risk agents, and conversely, for a single risk event to be caused by one or more underlying factors. To gather information on these risk agents, in-depth interviews were conducted with key informants, and direct observations were made in the shipping store area. Furthermore, an occurrence assessment was performed based on the frequency analysis of events reported in the IMC report.

Table 3. Some of risk event & risk agent

C	Risk Event	S	C	Risk Agent	O
Packing Process			A1	Insufficient workspace area	2
E1	Unreported abnormalities during receipt of goods	6	A2	Careless inspaction of products	5
E2	Excess quantity (wafer box)	6	A3	Error or malfunction in the SAP	5
E3	Damaged wafer product box	3	A4	Inadequate monitoring of packing operations	5
E4	Inspection failure during lot reception	6	A5	Non-compliant material used	2
E5	Loose pallet strapping	5	A6	Incomplete packaging	6
E6	incorrect packaging	5	A7	Individual team members performance is below standard	6
E7	Insufficient stretch wrap	4	A8	Insufficient sealing	5
E8	Failure to use protective materials (foam)	3	A9	Improper pallet stacking	6
E9	Substandard cardboard pallet	5	A10	Inadequate maintenance equipment and machinery	3
E10	Failure to rewrap the box	3	A11	Container sealing not strong	5

C	Risk Event	S	C	Risk Agent	O
E11	Substandard equipment or tooling	2	A12	Container leakage	4
E12	Loss due to human error during manual handling	8	A13	Excessive humidity in the container	4
Shipment Process			A14	Improper oversight of loading process	6
E13	Pallet box dented	5	A15	Improper container inspection	4
E14	Pallet box damage	8	A16	Container collision	6
E15	Receipt of damage carton shipment from Batam without accompanying damage survey report	8	A17	Overloading of shipment	3
E16	Product packaging damage due to puncture at the base	7	A18	Forwarders omission	6
E17	Pallet loading error due to misalignment	7	A19	Incompetent driver	3
E18	Product packaging mismatch issue	5	A20	Palletized goods are stored in a stacked configuration at the forwarders warehouse	4
E19	Inadequate securing of cargo during container loading	7	A21	Ineffective tracking and monitoring system	7
E20	Product packaging damage occurred during forwarder pickup due to accidental drop from trolley	7	A22	Insufficient communication with the forwarder	7
E21	Pallet carton damaged due to water exposure	7	A23	Inclement weather conditions	3

C=code ; S = Severity ; O = Occurance

As presented in Table 3, a total of 21 risk events were identified, and 23 risk agents were found to have an impact on these risk events, with the notable characteristic that a single risk agent can influence multiple risk events. Three risk events with a severity rating of 8 have been identified (E12, E14, E15) which can lead to severe consequences, including product returns. Two risk agents have been identified with an occurrence rating of 7, signifying a relatively high likelihood of occurrence compared to other agents

4.4 Identification of correlation between risk agents and risk event

The subsequent step involves evaluating the correlation or relationship between each risk agent and the corresponding risk event, utilizing a scoring system with values of 1, 3, and 9.

4.5 Aggregate Risk Potential of agent

The ARP calculation aims to establish a prioritization of risks that will be addressed through risk treatment or mitigation strategies.

Table 4. HOR1 of the case

E	Risk Agent (A)																						S
	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	
E1		9		3			3																	6
E2		9	3	3			3																	6
E3		9	3	3			3																	3
E4		9		3			3																	6
E5				9		3	9	9		3				3										5
E6				9		9	9	3	3					3										5
E7				3		9	3	9																4
E8		3				9	3																	3
E9				3	9	9	3			3														5
E10				3		9	9																	3
E11	3			3			9	3	3	3														2
E12				3			3			9														8
E13					3	3		3			3			3	3	3		3						5
E14					3	9	3	3	3		3	3	3	9	3	3	3	9	3	3	3	3	3	8
E15							3							3	3			3			3	9		8
E16										3				3				3						7
E17							9		9		3			3				3						7
E18				3			3			3														5
E19							3							9	3									7
E20																		9	3					7
E21												9	3		9					3	3	9	7	
O	2	5	5	5	2	6	6	5	6	3	5	4	4	6	4	6	3	6	3	4	7	7	3	
ARP	12	990	135	1170	168	1692	2430	705	648	432	300	348	180	1476	588	234	72	1296	135	96	483	819	261	14670
Rk	23	6	19	5	18	2	1	8	9	12	14	13	17	3	10	16	22	4	20	21	11	7	15	

Upon completing Phase 1, which involves risk event identification, severity assessment, risk agent identification, occurrence rate evaluation, correlation analysis, and ARP calculation, the next step is to create a Phase 1 Heatmap Table to prioritize risk agents based on their ARP values. According to Table 4. the risk agent with the highest aggregate risk potential is A7, underperforming team members, with a score of 2,430. Conversely, the risk agent with the lowest aggregate risk potential is A1, inadequate workspace, with a score of 12.

4.6 Identification and Prioritization of Proactive Actions

The Pareto Diagram is employed to identify and prioritize the risk agents that require proactive actions, enabling the organization to focus on the most critical risks that need to be addressed

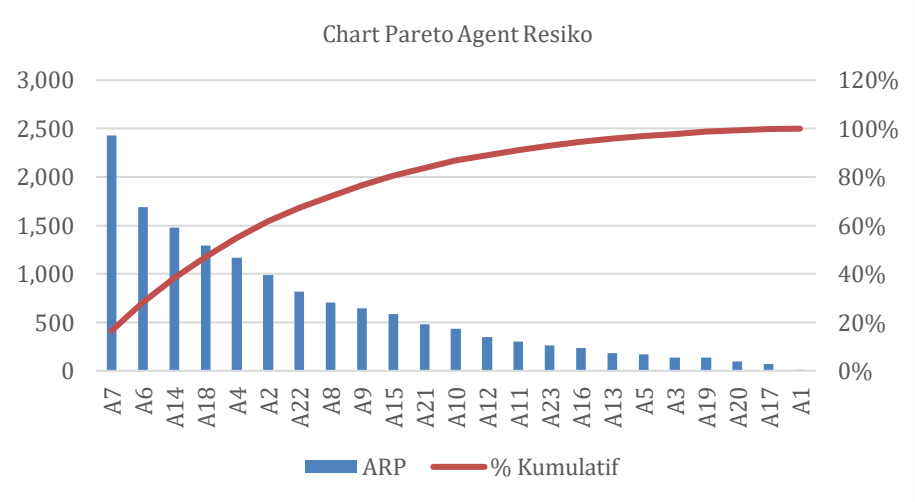

Fig. 2. Pareto diagram of aggregate risk potentials of all risk agents

The Pareto diagram in Figure 2 illustrates the risk agents. Following an agreement with the shipping store, the top 5 risk agents contributing approximately 55% of the total Aggregate Risk Potential (ARP) were selected, as they pose the most significant threats and require immediate attention. As per Table 5, after analysis, the 5 selected risk agents are: Individual team members performance is below standard (A7), Improper pallet stacking (A6), Improper oversight of loading process (A14), Forwarders omission (A18), and Inadequate monitoring of packing operations (A4).

Having identified the priority risk agents, the next step is to develop a strategy to mitigate the likelihood of these selected risk agents occurring. A total of 12 risk mitigation strategies are recommended for implementation by PT XY, focusing on the 5 priority risk agents that require immediate attention and mitigation efforts:

Table 5. Preventive Action

Code	Preventive Action (PA)
PA1	Installing CCTV in the shipping area to monitor the packing proccess
PA2	Installing CCTV in the shipping area to monitor the loading proccess
PA3	Implementing enhanced surveillance protocols in the packing process area
PA4	Conducting a re-check on the pallet before loading
PA5	Reviewing procedures to prevent similar errors in the future
PA6	Implementing enchanced surveillance protocols in the loading process area
PA7	Re-training all forklift operators
PA8	Promoting work-life balance for employees
PA9	Improving team collaboration
PA10	Implementing regular performance assessments for the shipping team
PA11	Conducting re-inspections of containers
PA12	Enhancing intensive communications with forwarders

Table 6 outlines the proposed risk mitigation strategies for implementation in the shipping section. Prior to implementation, it is essential to prioritize the strategies based on their effectiveness, ensuring that resources and costs are utilized efficiently. However, there are still unresolved issues that require further analysis using the House of Risk (HOR) phase 2. Subsequently, an evaluation will be conducted to assess the correlation between the recommended risk mitigation strategies and the identified risk agents. This will be followed by calculations of total effectiveness (TE), degree of difficulty (Dk), and the effectiveness-to-difficulty ratio (ETDk). The ETDk ratio will serve as a decision-making tool to determine which strategy should be implemented first, based on its ETDk value.

Table 6. HOR 2 of the case

Code	Preventive Action (PAk)												ARP
	PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8	PA9	PA10	PA11	PA12	
A7	3	3	3		3	3	9	3	3	3			2,430
A6		3		3	3	3				3			1,692
A14		9			3	3				3	3		1,476
A18		3									3	9	1,296
A4	9		3	3									1,170
Tek	17,820	29,538	10,800	8,586	16,794	16,794	21,870	7,290	7,290	16,794	8,316	11,664	
Dk	3	3	4	3	3	4	3	3	4	4	3	3	
ETD	5,940	9,846	2,700	2,862	5,598	4,199	7,290	2,430	1,823	4,199	2,772	3,888	
Rank	3	1	10	8	4	5	2	11	12	6	9	7	

According to Table 7, the House of Risk phase 2 analysis produced the results of the Tek, Dk evaluation, ETD calculation, and ETD ranking. The ranking of the effectiveness-to-difficulty (ETD) values for the proposed handling strategies reveals that the strategy with the highest ETD value is the installation of CCTV in the shipping area to monitor the loading process (PA2), with an ETD of 9.846, making it the most ideal mitigation action. In contrast, the strategy with the lowest ETD value is enhancing team collaboration (PA9), with an ETD of 1.823. A higher ETD value indicates that a handling strategy or mitigation is relatively easier to implement compared to one with a lower ETD value.

5 Conclusion

Based on the findings and analysis, the following conclusion can be drawn: The initial risk identification process, which involved interviews and business process grouping into two categories, namely packing and shipping, yielded 21 risk events at PT XYZ.

The analysis revealed 23 risk agents that contribute to 21 risk events. Using the Aggregate Risk Potential (ARP) calculation, 5 risk agents were identified as high-priority for mitigation, collectively accounting for 55% of the total ARP value. These priority risk agents are: underperforming team members (A7), incomplete packing (A6), inadequate loading process supervision (A14), forwarder negligence (A18), and lack of work supervision during packing (A4).

To mitigate the 5 identified risk agents, 12 handling strategies have been proposed for implementation by the company. The most ideal strategy, with the highest ETD value, is to install CCTV in the shipping area to monitor the packing process. Each strategy can be implemented by PT XYZ in order of their ETD ranking, from highest to lowest, based on their ease and effectiveness. It is expected that these 12 recommended strategies will provide alternative solutions and risk mitigation measures to address the issue of damaged goods at PT XYZ, particularly in the shipping section, Future research directions could involve exploring a distinct population, for instance, by broadening the study to encompass other pertinent groups, including production and forwarder entities.

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