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RISK ANALYSIS OF AUTOMATED STACKING CRANE (ASC) TERMINAL TELUK LAMONG USING FMECA METHOD BASED ON ISO 31000 : 2009

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ABSTRACT

Terminal Teluk Lamong is a green port that was established as deep port to support Indonesia's Sea Toll program. The management employs Automatic Stacking Crane (ASC) as one of the equipment to reduce emission. Unfortunately, the equipment is relatively new to Indonesians. Several costly and dangerous accidents have taken place due to inexperienced employees and lack of risk management implementation for ASC. Thus, risks management is required in this case. In this study, risks were identified using Delphi Method. The identified risks were then evaluated and ranked using FMECA. Based on the result, the risks were then mapped to determine their category in the company risk profile. In addition, DEMATEL method was employed to understand and analyze the correlation between two or more risks. Based on the result of risk evaluation, there were 19 high risks, 7 medium risks, and 30 low risks. Finally, risk mitigation strategies were proposed based on the treatment required by the company for each risk.

Keyword: Risk Management, Delphi, FMECA, DEMATEL, Port, Automatic Stacking Crane

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PREFACE

Bismillahirrahmanirrahim.

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CHAPTER 1
INTRODUCTION

This chapter will explain the background of the project, problem formulation, purposes, benefits, and the outline of the report.

1.1 Background

Indonesia is an archipelago country with more than 17.000 islands, as stated in United Nation Convention of Law on The Sea (UNCLOS) 1982. With geographic structure and location dominated by the sea, Indonesia is in 3rd place to have the longest coastline in the world (CIA World Fact Book, 2018). As an archipelago country, it means sea has a signification function in Indonesia's prosperity. By nature, sea has big influence on transportation mode to distribute product throughout the country. Sea transportation is dominating as transportation mode, accounted 88% of total movement in Indonesia (Zaman and Vanany, 2014).

With situation aforementioned, it is become the government attention to improve the facilities and infrastructure related to the sea. Since 2015, in the spirit to increase our country's welfare, Indonesia constructs *Rancangan Program Jangka Panjang Nasional* (RPJPN) year 2005 – 2025, with purpose to create Indonesia as independent, developed, and strong archipelago country. In year 2017, funds for infrastructure purposes are higher than other sectors. As stated in *Anggaran Pendapatan dan Belanja Negara* (APBN) 2017, government prioritizes infrastructure development, with 387.3 trillion rupiah budget, increase 123,4% than the year prior (Kementerian Keuangan, 2017).

"Sea Toll" program is one of the government projects to utilize the use of sea to our advantage. The idea is, sea increase the interconnectedness amongst island. The cheapest way to distributes product throughout the country is using sea. Yet, there are some commodities do not reach certain areas. This is caused by there are not enough demand in the place. Besides, the depth of the port available is not sufficient.

The government then makes the plan. First, they will subsidize the transportation cost for the distributor. As the time goes, the commodities will always available in the areas, and push the demand, thus the distributor later is willing to ship their products there.

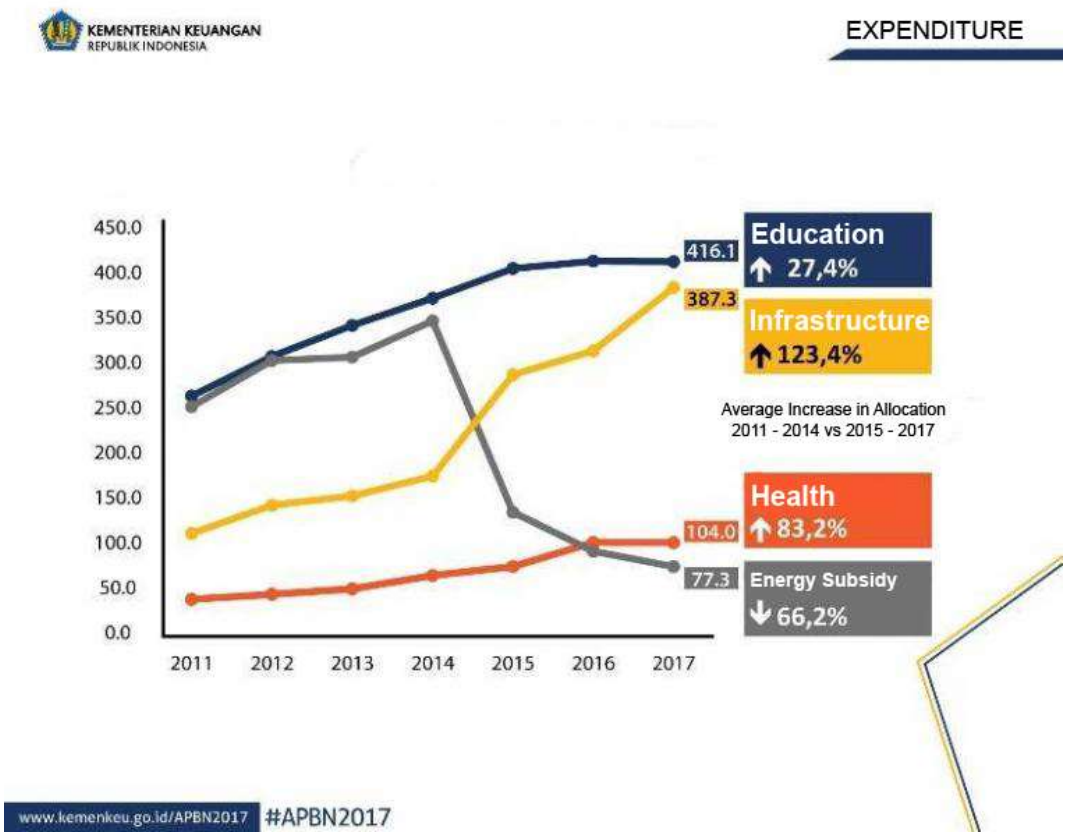

Figure 1. 1 Infrastructure Funding based on APBN 2017
(Source: kemenkeu.go.id 2018)

However, even if the case of distributor willingness is solved, there is one other problem: the facilities. Usually, a big ship is being used by the distributor to send the product away. Unfortunately, big ship means deeper sea port, and Indonesia has a lack of deep sea port.

Along with the program, it makes sense the government builds ports and shipyard hence the economics activities are pumped up in all areas in Indonesia. Now, Indonesia still has a problem about the location and quantity ports and shipyard. One of the Deep Sea Port the government builds is Terminal Teluk Lamong.

Figure 1. 2 Ports to be Developed under The "Sea Toll" Road Programme
(Source : BKPM, Ministry of National Development Planning, 2018)

Terminal Teluk Lamong is one of the ports build to support sea transportation. As multipurpose terminal engaged in container and dry bulk services, its goals is to smooth "Sea Toll" program.

Terminal Teluk Lamong is a subsidiary of Pelindo III. The port puts forward the service with the high-tech facilities, carrying the concept of "The First Green Port in Indonesia".

The operation of the Domestic Pier is done on 13 November 2014. Terminal Teluk Lamong is inaugurated on 22 May 2015 after the concession agreement of The Ministry of Transportation and Pelindo III on 19 May 2016. The implementation of the concession agreement is the affirmation of Article 344 of Law 17/2008 in conjunction with Article 165 PP 61/2009.

Due to its concept, Terminal Teluk Lamong is established as green port. The Green Port Program is an umbrella program designed to achieve the port's environmental sustainability goals in six keys areas: water, energy, air, waste management, sustainable development, and sustainable business practices (Port of San Diego, 2018).

Terminal Teluk Lamong has advanced facilities compare to other ports in Indonesia such as Pelabuhan Tanjung Priok. Almost all of the equipments and tools used in the operation process of the yard, sea ways, and docks are at least semi-automated.

Terminal Teluk Lamong is listed as the 4th most sophisticated port in the world. It can be seen by the use of Automated Stacking Crane (ASC). Automated Stacking Crane (ASC) is used by Terminal Teluk Lamong as substitutes to Rubber Tyred Gantry (RTG). It is used to

stack container in blocks, land-side or water side. ASC is the semi-automated version of RTG.

The use of ASC has several advantages. First, higher effectiveness and efficiency of port activities as less operators and administrator needed. Second, eco-friendly equipment because it uses electricity, thus there is less air pollution, noise pollution, and vibration. Third, stable productivity since it is capable to work 24 hours a day. And last, paperless, since all of the administration activities are done via IT system, so that reduce the meetings between customer and employees, and minimize the occurrence of authority abuse (Cameron and Raman, 2005).

ASC uses in Terminal Teluk Lamong does increase the productivity. Nevertheless, there is something missing in the operation process: risk management. Risk management is defined as coordinated activities to direct and control an organization's risk, defined as a combination of an event's consequences and their associated likelihood (AS/NZS ISO 31000:2009, 2009). There are many reasons why the technical and operational risks in an organization must be assessed: regulatory requirements, common law duty of care, commercial reasons, and evaluation of alternative options (Cameron and Raman, 2005). It is encompassing activity for a range of other tasks that include at the very least: 1) Risk assessment (analysis and evaluation); 2) Risk treatment (elimination, mitigation, transfer); 3) risk acceptance (tolerability/acceptability criteria); 4) Risk communication (information sharing with stakeholders); and 5) Risk monitoring (auditing, evaluation, compliance). Figure 1.3 shows a schematic representation of risk management concepts similar to the Australian Standard AS4360 2004.

Risk management is a life cycle concept, since it is both multifaceted in addressing a range of risks; it is active throughout the life cycle of the process or product; it is multidisciplinary since it can cut across all levels of the corporation, government authorities, and local communities; it is dynamic in nature due to an ever-changing environment of legislation, expectations, technology, and business pressures.

Terminal Teluk Lamong actually already developed corporate risk management for their business, yet they still do not have the specific risk management for all of their equipment. ASC is one of them.

In the past, there are some accidents happened around ASC equipment. It is costly, and dangerous to the containers. Moreover, it affects company's credit in the eyes of customers. Some of the accidents are fixed immediately. However, Terminal Teluk Lamong

feels the need to build a plan in order to avoid accidents. Since for the longest time they only react on it rather than prevent. Nevertheless, in advance to prevent the accidents which may occur in the future, Terminal Teluk Lamong need to develop the risk management first.

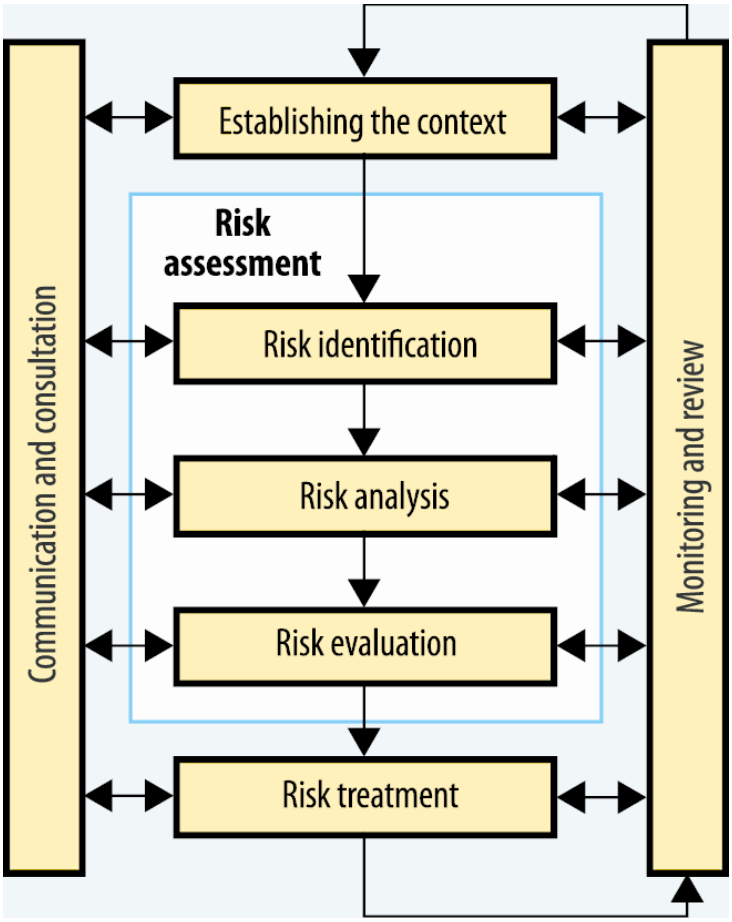

Figure 1. 3 Overview of Risk Management
(Source: Cameron and Raman, 2005)

To solve the problem, the aim of this research is to design risk profile based on the ASC equipment of Terminal Teluk Lamong. The method is being used to identify risk is Delphi Method, to develop the risk assessment is Failure Mode, Effect, and Criticality Analysis (FMECA). It is a step-by-step approach for identifying all possible failures in a design, a manufacturing or assembly process, or a product or services. To see the relationship of each risk Decision Making and Trial and Evaluation Laboratory (DEMATEL) will be used as a method.

1.2 Problem Formulation

Terminal Teluk Lamong has not implemented a well-established risk management for ASC equipment. Thus, the problem which will be solved in this final project is how to identify, assess, evaluate, and mitigate the risk related to ASC equipment.

1.3 Purposes

The purposes of this research are namely as follows:

1. To apply a risk analysis using FMECA methodology;
2. To create the risk mapping based on Risk Priority Number which has been identified in advance;
3. To plan the action towards the identified risks based on the available alternative;
4. To design a user interface to display the company's risk profile for ASC equipment to help the company monitoring the risks.

1.4 Benefits

The benefits from the final project are developing potential failure mode, effect, and criticality analysis and the recommended action to ensure that the potential of hazard is not realized, and should it be realized, the consequences are mitigated, related to ASC.

1.5 Limitation and Assumption

Limitations and assumptions of the final project are needed to simplify the problem are listed as follows.

1.5.1 Limitation

1. The data used is limited on year 2017.
2. The object for analysis is limited only for ASC.
3. The research not consider time frame.

1.5.2 Assumption.

1. The pattern of accident for risk identification and analysis is neglected.

1.6 Report Outline

CHAPTER 1 INTRODUCTION

This chapter discuss about background, problem formulation, research purposes, research benefits, limitation and assumption, and report outline. In background, the company where the internship is done is explained; along the main focus on the project and method used. Meanwhile, research purposes consist of the purposes that are hoped to be achieved due to the project. The benefits are the extension of the purposes, impact of the research well done. Limitation and assumption lists the limit of the research and the assumption of the situation and condition of the company. Last, report outline will describe content of each chapter.

CHAPTER 2 LITERATURE REVIEW

This chapter consists of references used by author to help determining the method so it will suit the problem of the company. The reviews will be about Risk, Risk Management, Green Port, Delphi Method, Failure Mode, Effect, and Criticality Analysis, and Decision Making and Trial and Evaluation Laboratory.

CHAPTER 3 METHODOLOGY

This chapter consists of the steps that must be done by author hence the research could be done structurally, well-directed, and systematic. The methodology consists of identification and problem formulation phase, data collection, data processing, analysis and interpretation, and conclusion and suggestion formulation.

CHAPTER 4 DATA COLLECTING AND PROCESSING

This chapter consists of the data collection and the process to solve the problem in the company and achieve the research purpose. The data which is being collected are company profile, incident and accident record, ASC manual, standard operation procedures, stakeholder related to ASC, and corporate risk.

CHAPTER 5 DATA ANALYSIS AND INTERPRETATION

This chapter consists of the analysis of collected data. Then, the detail interpretation will be done based on the analysis. The result will be used as guidance in order to draw conclusions and suggestions.

CHAPTER 6 CONCLUSION AND SUGGESTION

This chapter consists of the conclusion from the project to answer the research purpose and the recommendation for the next project.

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CHAPTER 2
LITERATURE REVIEW

The ground theories used in this research are: risk; risk management; green port; Delphi; Failure Mode, Effect, and Criticality Analysis; Decision Making and Trial and Evaluation Laboratory; and the review of previous research.

2.1 Risk

Often, risk is seen as something negative to an individual or organization. It is not seldom defined as loss, dangerous, and other consequences. As stated by Frosdick (1997), risk is more likely to be attributed with loss due to incident which may happen in certain period. However, risk does not always meant to be negative consequences; it also can be treated to bring positive effect, called as opportunity, whereas risk brings negative effects called threat.

According to Australian New Zealand Standard (AS/NZS) 4360:2004, risk is the effect of uncertainty on objectives and measured by likelihood and consequences. According to Monahan (2008), risk definition is uncertainty, results in distribution due to one or several events.

Usually, risk can be calculated by multiplying likelihood and consequences. Likelihood is the score for probability and frequency of an event, generally used historical data to estimate, whilst consequences is the effect of the occurrence of an event, expressed by loss. Consequences also can be defined as range of result possibility due to the occurrence of an event (AS/NZS, 2004).

2.1.1 Dimensions of Risk

According to Anityasari and Wessiani (2011), there are several risk types an organization may run into.

1. Operational risk, risk related to operational activities in an organization. The factors of undesirable risk are: failed functioning system, technology, human resource, and others. Operational risk can be categorized into four sections, namely as follows.
    a. Productivity Risk, related to deviation from the result expected due to disparity of variables which affect productivity, such as technology, materials, tools, and human resource.

b. Technology risk, related to deviation from result expected caused by the technology is not accordance to the existing condition.
c. Innovation Risk, result is not as expected due to innovation, modernization, or transformation in several business aspects.
d. System Risk, part of process risk due to defect or incompatibility of system to organization operational activities.

2. Financial Risk is risk related to the financial condition of an organization. Financial risk can be categorized into five sections as follows.
   a. Finance Risk, related to fluctuation on financial target due to uncertainty in macro-variables.
   b. Liquidity Risk, related to uncertainty or possibility of an organization do not fulfill short term debt or unexpected expenses. This risk can also define as a possibility of selling organization's asses by loss caused by low sales.
   c. Credit Risk, related to possibility debtor and credits customer cannot pay their debt and fulfill their obligation as stated in the deal prior to the sales.
   d. Market Risk, related to the potency of financial condition in the market caused by uncertainty in the market and the organization have to adjust their condition to the market (mark to market). These risks can be divided into interest risk, exchange rate risk, commodity risk, and equity risk.
3. External Risk, related to the possibility of unexpected result to corporation exposure and strategy. It may cause a business to be closed down. External risk can be categorized into four sections, namely as follows.
   a. Reputation Risk, related to the loss or destruction of an organization reputation due to low or none of environment acceptance to the business.
   b. Environment Risk, related to the possibility the organization unable to manage the waste and pollution or the effect of waste management.
   c. Social Risk, related to the possibility of unexpected result since the organization failed to familiarize themselves to the community around.
   d. Law Risk, related to the possibility of unexpected result as the organization fail to follow the regulation.
4. Strategic Risk, related to risk which may affect organization's exposure as an effect of unsuitable strategic decision to the external and internal environment. Strategic risk can be categorized into three sections, namely as follows.

a. Business Risk, the possibility of unachieved targets in terms of value of the business, stocks, and finance, because the organization enter a certain business with unique industry environment and specific technology.
b. Strategic Transaction Risk, related to the possibility of unachieved corporation and/or business targets because of strategic transaction.
c. Investor Relationship Risk, related to the possibility of differences in financial target and exposure as the organization's imperfect relationship handling with investor, either stock-holder or creditor.

2.1.2 Risk Cause

According to Kasidi (2010), there are two factors caused a risk to be considered, which are disaster and hazard.

1. Disaster is an activity that happened by natural causes, such as flood, earthquake, typhoon, etc.
2. Hazard is the background of loss. Hazard can be categorized into three categories.
    a. Physically hazard, is the physical aspect of the asset to risk. For example, a building which does not have fire equipment is in bigger risk than a building with fire equipment installed.
    b. Morale hazard is a hazard that may happen inflicted to careless attitude towards risk. For example, throwing away cigarettes butt randomly may cause fire.
    c. Legal Hazard, is the hazard happened because a fail action to follow regulation. For example, an operator who does not use personal protective equipment may cause accident fall onto him/her.

2.2 Risk Management

According to AS/NZS ISO 31000:2009 (2009), risk management is defined as "coordinated activities to direct and control an organization's risk, a combination of an event's consequences and their associated likelihood". In other words, risk management is a tool to manage risk effectively. Managing risks also refers to the application of principles, framework, and process to particular risks. As stated by Vaughan (2008), risk management is a scientific approach to handle risk by determines anticipation steps of the probability of loss, and design and implements procedures to minimize financial loss.

Goals of risk management as tools for an organization to achieve their objective by resource allocation to build plan, take a decision, and work productive. Below is the steps of risk management as stated by ISO 31000:2009 from Cameron and Raman (2005).

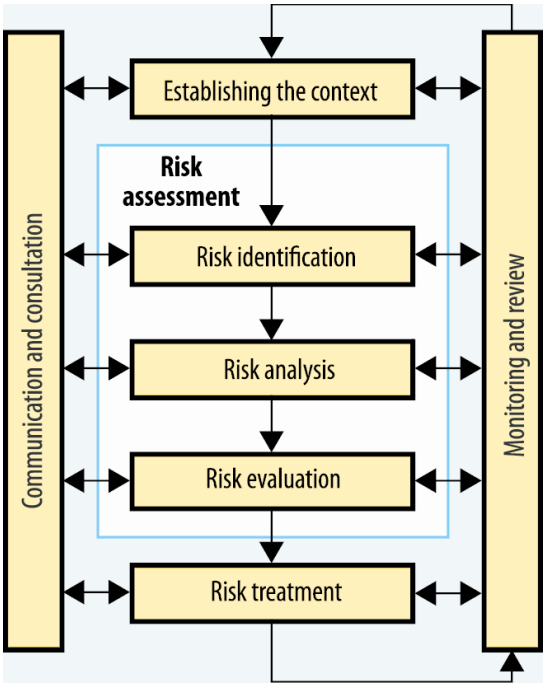


Figure 2. 1 Overview of Risk Management
(Source: AS/NZS, 2009)

The explanation of Figure 2.1 for risk management overview will be presented below based on handbook of risk management by Adelaide University.

1. *Establishing the context* by identifying the objectives of the project, event, or relationship. Then, the internal and external parameters need to be considered within which the risk must be manage. The risk management process applies equally to risks that arise at an enterprise wide or strategic level, at an operational or day-to-day business level or for new partnership projects, and new initiatives. In this process identifying the purpose and objectives are done right at the beginning; focus at the outset of the risk assessment to avoid being overwhelmed by details and data. Establishing the context also means to sets the framework within which the risk assessment should be undertaken, ensures the reasons for carrying out the risk assessment are clearly known, and provides the backdrop of circumstances against which risks can be identified and assessed. The process are : set the scope; define broad objectives; identify the relevant stakeholders; gather background information; and establishing the context.

2. *Risk assessment* phase is the steps of risk identification, risk analysis, and risk evaluation. It is well suited to a structured and systematic approach.
   a. *Risk identification*, involves identifying sources of risk, areas of impact, events and their causes and consequences. By describing these factors, it may create, enhance, prevent, degrade, accelerate, or delay the achievement of your objectives. The aim is also to identify the issues associated with not pursuing an opportunity; that is, the risk of doing nothing and missing an opportunity. It is recommended to embrace 5W+1H types of questions.
   b. *Risk analysis*, once the risk has been identified and the context, causes, contributing factors and consequences have been described; the strengths and weaknesses of existing systems and processes need to be observed thus the design may help control the risk. This process also includes identifying the existing controls and determining what controls are already in place to mitigate the impact of the risk. Once the controls have been identified and their effectiveness analyzed, an assessment is made based on the likelihood of the risk occurring and the consequence if the risk were to occur. Then, assess the likelihood and consequences. The assessment of likelihood and consequence is mostly subjective, but can be informed by data or information collected, audits, inspections, personal experience, corporate knowledge, or institutional memory of previous events, insurance claims, surveys, and information available. After that, the level of risk is rated using risk matrix.

Table 2. 1 Scale of Likelihood Score

Likelihood	Possibility of Occurence
Rare	less than 5%
Unlikely	5% - 25%
Possible	25% - 50%
Likely	50% - 75%
Almost Certain	more than 75%

Source: AS/NZS ISO 31000:2009 (2009)

Table 2. 2 Scale of Consequences Assessment

Consequences	Possibility of Occurence
Insignificant	No injuries, low financial loss
Minor	First aid treatment, medium financial loss
Moderate	Medical treatment required, high financial loss
Major	Extensive injuries, loss of production capability, major financial loss
Catastropic	Death, huge financial loss

Source: AS/NZS ISO 31000:2009 (2009)

c. *Risk evaluation* is the process to decide whether the risk is acceptable or unacceptable. Decisions about the future actions may include not to undertake or process with the event, activity, project, or initiative, actively treat the risk, prioritizing the actions needed, if the risk is complex and treatment is required, and accepting the risk. Whether a risk is acceptable or not, it is related to the willingness to tolerate the risk and bear the risk after it is treated in order to achieve the desired objectives. The *attitude* (organization's approach to assess and eventually pursue, retain, take, or turn away from risk), *appetite* (the amount and type of risk that an organization is willing to pursue) and *tolerance* (an organization's or stakeholders' readiness to bear the risk after risk treatment in order to achieve its objective) for risk is likely to vary over time.

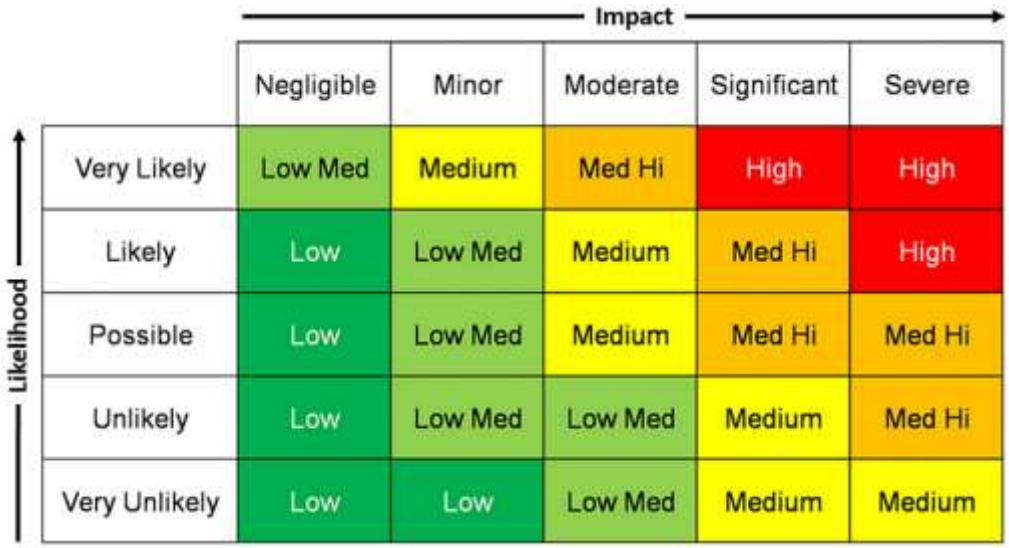


FIGURE 2. 2 Example of Risk Matrix
(Source : ARMS, 2018)

3. *Risk treatment* is the process to ensure that effective strategies are in place to minimize the frequency and severity of the identified risk. Then, to control the risk, actions and treatments must be developed and implemented. Where options for treatment are available and appropriate, record those treatment options as part of the risk treatment plan. The processes are: decide if specific treatment is necessary; work out what kind of treatment is desirable for the risk; identify and design a preferred treatment option; evaluate treatment options; document the risk treatment plan; implement agreed treatment; and assess the level of residual risk.
4. *Monitor and review* is a planned part of the risk management process. To ensure structured reviews and regular reporting occurs, each parts of organization is encouraged to identify a process that allows key risk within thire reach to be monitors. The processes are: continuous monitoring, department review; internal audit; external audit; and local coordination or risk facilitators.
5. *Communicate and consult* with internal and external stakeholders during any and all stages of the risk management process, particularly when plans are being frist considered and when significant decisions need to be made. In this step, several methods may be used to ensure that those responsible for implementing risk management are kept properly informed.

2.3 Green Port

The concept of "Green Port" development is the integrationof the environmental friendly method of port activities,operations and management (Badurina, et al., 2017). There are several ways to define measures for the establishment of ecological/green seaports. Examples of measures are: the implementation of policies relevant for the reduction of theemissions of harmful substances into the atmosphere, thelandscape design of an appropriate seaport which includes trees that absorb noise and pollution, etc. Moreover, measures include the use of renewable energy port operations and activities, recycling and reuse of materials. One of the main measures for the application of the concept of "GreenPort" development is the inclusion of the term "green"growth in the further development of the port systemsand the establishment of environmental planning withinthe mentioned areas.

According to Port of San Diego (2017), there are six main keys of Green Port Program. Below is the explanation of each key.

Table 2. 3 Green Port Intiatives

Initiatives	Goal	Objectives
Energy	*Conserve energy and maximize energy efficiency of Port operations.*	Implement recommendations outlined in San Diego Gas & Electric's Energy Road Map to reduce energy use. • Reduce the Port's operational energy use by at least 170,000 kilowatt hours per year. • Conduct a lighting pilot project to assess various energy efficiency technologies.
		Investigate opportunities to participate in renewable energy projects. • Conduct a solar assessment to determine optimal locations for future photovoltaic systems on tidelands and estimated costs of implementation. • Install photovoltaic systems on the Administration and General Services Buildings. • Pursue funding for other solar projects.
Waste Management	*Reduce waste from Port operations through material reuse, recycling and composting.*	Divert four tons of waste from the landfill. • Explore ways to enhance the composting program. • Expand collection opportunities for electronic waste. • Investigate opportunities to expand the Port's current recycling program.
Sustainable Development	*Enhance the environmental performance of Port buildings while maximizing long-term economic benefits.*	Adopt a Sustainable Building Policy.
		Enhance the environmental performance of two Port buildings. • Acquire LEED certification for the Administration Building. • Acquire LEED certification for the General Services Building. • Continue work on LEED certification for Broadway Pier. • Educate key Port employees on sustainable building principles.
Water	*Improve water quality in San Diego Bay and reduce the Port's water usage to preserve San Diego's water supply.*	Reduce the Port's operational water use to beyond local regulations. • Conduct a sustainable landscaping project at a Port park. • Develop and implement a water conservation strategy. • Replace plumbing fixtures in Port buildings with water efficient fixtures. • Explore opportunities to expand the Smart Irrigation System on tidelands.
Air	*Reduce greenhouse gas contributions and other air emissions from Port operations.*	Develop and implement a carbon footprint management program. • Define and publicly register the carbon footprint of Port operations, and establish goals to maintain or reduce this footprint. • Explore ways to assist tenants in measuring and reducing their carbon footprint.
		Continue implementation of the Clean Air Program. • Monitor the success of the Vessel Speed Reduction Program. • Continue work on shore power installation. • Implement a tenant-owned cargo handling equipment retrofit and/or replacement program that maximizes available/potential funding.

Table 2. 4 Green Port Intiatives (con't)

Initiatives	Goal	Objectives
Sustainable Business Practices	*Give equal weight to environmental, economic and social concerns in the decision-making process.*	Increase opportunities for employees and the public to participate in the Green Port Program to learn about ways to be more sustainable. • Establish the Port as a drop-off location for a Community Supported Agriculture Program. • Increase outreach efforts as part of the Green Port Education Program. • Continue the Commuter Assistance Program. Objective: Expand the use of environmentally-friendly products used in Port operations. • Develop and implement a Green Housekeeping Standard Operating Procedure. • Conduct a pilot Green Purchasing Program.

Source: Port of San Diego, 2017

The use of Automated Stacking Crane in Terminal Teluk Lamong is actually to support Energy initiatives, since the use of ASC is using electricity, not solar like Rubber Tyred Grant that is used in common port.

2.4 Delphi Method

The Delphi method is a forecasting method based on the results of questionnaires sent to a panel of experts. Several rounds of questionnaires are sent out, and the anonymous responses are aggregated and shared with the group after each round. The experts are allowed to adjust their answers in subsequent rounds. Since multiple rounds of questions are asked and the panel is told what the group thinks as a whole, the Delphi method seeks to reach the correct response through consensus.

The Delphi method was originally conceived in the 1950s by Olaf Helmer and Norman Dalkey of the Rand Corporation. The name refers to the Oracle of Delphi, a priestess at a temple of Apollo in ancient Greece known for her prophecies. The Delphi method allows experts to work towards a mutual agreement by conducting a circulating series of questionnaires and releasing related feedback to further the discussion with each subsequent round. The experts' responses shift as rounds are completed based on the information brought forth by other experts participating in the analysis (Yousuf, 2007).

2.4.1 Delphi Method Procedure

According to Haughey (2013), generally there are seven steps required to get the result from Delphi Method procedure.

1. Choose a facilitator. This role may be taken by the author, or a neutral person within organization. It is useful to have someone that is familiar with research and data collection.
2. Identify Experts. The Delphi technique relies on a panel of experts. This panel may be the project team, including the customer, or other experts from within the organization or industry. An expert is any individual with relevant knowledge and experience of a particular topic.
3. Define the problem. The experts need to know what problem they are commenting on, so a precise and comprehensive definition must be provided.
4. Round-One questions. Ask general questions to gain a broad understanding of the experts view on future events. The questions may go out in the form of a questionnaire or survey. The result then collated and summarized, removing any irrelevant material and looking for common viewpoints.
5. Round-Two questions. Based on the answers to the first questions, the next questions should delve deeper into the topic to clarify specific issues. These questions may also go out in the form of a questionnaire or survey. The result then collated and summarized, removing any irrelevant material and look for the common ground.
6. Round-Three questions. The final questionnaire aims to focus on supporting decision making. Hone in on the areas of agreement to know what the experts are all agreed upon is.
7. Act on Findings. After this round of questions, the experts will have reached a consensus and future events can be viewed. Analyze the findings and put plans in place to deal with future risks and opportunities to the project.

2.4.2 Advantages and Disadvantages of Delphi Method

The Delphi method seeks to aggregate opinions from a diverse set of experts, and it can be done without having to bring everyone together for a physical meeting. Since the responses of the participants are anonymous, individual panelists don't have to worry about repercussions for their opinions. Consensus can be reached over time as opinions are swayed.

While the Delphi method allows for commentary from a diverse group of participants, it does not result in the same sort of interactions as a live discussion. Response times can be long, which slows the rate of discussion. It is also possible that the information received back from the experts will provide no innate value.

2.5 Failure Mode, Effect, and Criticality Analysis (FMECA)

In the late 1940s, the US military was committed to change from an approach of "find failure and fix it" to "anticipate failure and prevent it". The methods developed focused on qualitative and quantitative risk identification for preventing failure. Failure Mode, Effects & Criticality Analysis (FMECA) is a method which involves quantitative failure analysis. The FMECA involves creating a series of linkages between potential failures (Failure Modes), the impact on the mission (Effects) and the causes of the failure (Causes and Mechanisms). The methods and techniques associated with the FMECA were published in a series of Military Standards. MIL-STD-1629A is the most prominent of these standards and is still in use today.

FMECA and Failure Mode and Effects Analysis (FMEA) are closely related tools. Each tool resolves to identify failure modes which may potentially cause product or process failure. FMEA is qualitative, exploring "what-if scenarios", where FMECA includes a degree of quantitative input taken from a source of known failure rates.

2.5.1 FMECA Procedures

According to McDermott et al., 2009, there are ten steps need to be followed to conduct FMECA procedures, namely as follows.

a. Review The Process

In the process of conducting FMECA, the team should review a detailed flowchart of the operation to ensure everyone on the team has the same understanding of the process. If the flowchart is not available, team should make the flowchart first, by physically walk through the process exactly as the process flows with the assistance of an expert.

b. Brainstorm Potential Failure Modes

After the process has been understood, team members can begin thinking about potential failure modes that could affect the process. Team members should come to the brainstorming meething with a list of their idea. It is better to conduct a series

brainstorming sessions, each focused on a different element. Then, the ideas should be organized by grouping it into categories. It gives a chance to the team to consider if some failure modes should be combined due to similarity. After that, when appropriate, the list should be moved onto the FMECA worksheet.

c. List Potential Effects of Each Failure Mode

With failure modes listed on the FMECA worksheet, the team reviews each failure mode and identifies the potential effects of each failure should it occur.

d. Assign Severity, Occurence, and Detection Ranking for Each Effect

Each of these ranking is based on a 10-point scale, 1 being the lowest ranking and 10 the highest. It is important to establish clear and concise description for the points on each of the scales, so all team members have the same understanding of the rankings. The scales should be established first before the ranking process beginning.The more descriptive the team is when defining the ranking scale, the easier reach consensus during the ranking process.

Below is the general scale for each rankings,

Table 2. 5 Generic Process FMECA Severity Evaluation Criteria

Effect	Criteria: Severity of Effect on Product	Rank	Effect	Criteria: Severity of Effect on Process
Failure to meet safety and/or regulatory requirements	Potental failure mode affects safe vehicle operation and/or involves noncompliance with government regulations without warning	1	Failure to meet safety and/or regulatory requirements	May endanger operator without warning
	Potental failure mode affects safe vehicle operation and/or involves noncompliance with government regulations with warning	2		May endanger operator with warning
Loss or degradation of primary function	Loss of primary function (vehicle inoperable, does not affect safe vehicle operation)	3	Major disruption	100% of product may have to be scrapped. Line shutdown or stop ship.
	Degradation of primary function (vehicle operable, but at reduced level of performance).	4	Signicifant disruption	A portion of the production run may have to be scrapped. Deviation from primary process including decreased line speed or added manpower.

Table 2. 6 Generic Process FMECA Severity Evaluation Criteria

Effect	Criteria: Severity of Effect on Product	Rank	Effect	Criteria: Severity of Effect on Process
Loss or degradation of secondary function	Loss of secondary function (vehicle inoperable but comfort/convenience functions inoperable)	5	Moderate disruption	100% of production run may have to be reworked off line and accepted
	Degradation of secondary function (vehicle inoperable, but comfort/convenience functions at reduced level of performance).	6		A portion of the production run may have to be reworked off line and accepted
Annoyance	Appearance or audible noise, vehicle operable, item does not conform and noticed by most customer (>75%)	7		100% of production run may have to be reworked in-station and accepted
	Appearance or audible noise, vehicle operable, item does not conform and noticed by many customer (50%)	8		A portion of the production run may have to be reworked in-station and accepted
	Appearance or audible noise, vehicle operable, item does not conform and noticed by discriminating customer (<25%)	9	Minor disruption	Slight inconvenience to the process, operation, or operator
No effect	No discemible effect	10	No effect	No discemible effect

Source: McDermott, et al., 2009

Table 2. 7 Generic Process FMECA Occurrence Evaluation Criteria

Likelihood of Failure	Occurrence of Causes – Incidents per item/vehicle	Rank
Very High	≥ 100 per thousand ≥ 1 in 10	10
High	50 per thousand 1 in 20	9
	20 per thousand 1 in 50	8
	10 per thousand 1 in 100	7
Moderate	2 per thousand 1 in 500	6
	0,5 per thousand 1 in 2000	5
	0,1 per thousand 1 in 10.000	4
Low	0,01 per thousand 1 in 100.000	3
	≤ 0,001 per thousand 1 in 1.000.000	2
Very Low	Failure is eliminated through preventive control	1

Source: McDermott, et al., 2009

Table 2. 8 Generic Process FMECA Detection Evaluation Criteria

Opportunity for Detection	Criteria Likelihood of Detection by Process Control	Rank	Likelihood of Detection
No detection opportunity	No current process control; Cannot detect or is not analysed	10	Almost impossible
Not like to detect at any stage	Failure Mode and/or Error (Cause) is not easily detected (e.g., random audits).	9	Very remote
Problem detection post processing	Failure Mode detection post-processing by operator through visual/tactile/audible means.	8	Remote
Problem detection at source	Failure Mode detection in-station by operator through visual/tactile/audible means or post-processing through use of attribute gauging (go/no-go, manual torque check/clicker wrench, etc.).	7	Very low
Problem detection post processing	Failure Mode detection post-processing by operator through use of variable gauging or in-station by operator through use of attribute gauging (go/no-go, manual torque check/clicker wrench, etc.).	6	Low
Problem detection at source	Failure Mode or Error (Cause) detection in-station by operator through the use of variable gauging or by automated controls in-station that will detect discrepant part and notify operator (light, buzzer, etc.). Gauging performed on setup and first-piece check (for set-up causes only)	5	Moderate
Problem detecting post processing	Failure Mode detection post-processing by automated controls that will detect discrepant part and lock part to prevent further processing.	4	Moderatly high
Problem detection at source	Failure Mode detection in-station by automated controls that will detect discrepant part and automatically lock part in station to prevent further processing.	3	High
Error detection and/or problem prevention	Error (Cause) detection in-station by automated controls that will detect error and prevent discrepant part from being made.	2	Very high
Detection not applicable; Error prevention	Error (Cause) prevention as a result of fixture design, not machine design or part design. Discrepant parts cannot be made because item has been error-proofed by process/product design.	1	Almost certain

Source: McDermott, et al., 2009

The best method for determining the occurrence ranking is to use actual data from the process, in the form of failure logs or even process capability data. If actual failure data are not availbale, the team must estimate how often a failure mode may occur.

Meanwhile, the detection ranking looks at how likely the team detect a failure or the effect of a failure. This step could be started by identifying current controls thay may detect a failure or effect of a failure. If there are no current controls, the

likelihood of detection will be low, and the item would receive a high ranking, such as 9 or 10.

e. Calculate The Risk Priority Number for Each Effect

The risk priority number (RPN) is simply calculated by multiplying the severity ranking times the occurence ranking time the detection raking for each item.

$$Risk\ Priority\ Number = Severity\ \times Occurrence\ \times Detection \qquad (2.1)$$

The total RPN should be calculated by adding all of RPN. This number alone is meaningless because each FMECA has a different number of failure modes and effects. Nevertheless, it can serve as a gauge to compare the revised total RPN once the recommended actions have been instituted.

f. Prioritize The Failure Modes for Action

The failure modes can be prioritized by ranking them in order from the highest RPN to the lowest. Usually the rule 80/20 are applied with the RPNs as it does with other quality improvement opportunities, example in Figure 2.3.

The team must now decide which items to work on. It may help to set a cutoff RPN, where any failure modes with an RPN above that point are attender to, and the one below the cutoff are left alone for the time being.

g. Take Action to Eliminate or Reduce The High-Risk Failure Modes

In order to eliminate or reduce any high-risk failure, the team may use an organized problem-solving process. Ideally, the failure modes should be eliminated completely. When a failure mode has been eliminated completely, the new RPN approaches zero because the occurence ranking become one. Often, the easiest approach for making a process improvement is to increase the detectability of the failure. However, these approaces ofter are costly and do not actually improve the process. Reducing severity is important, especially in situations that can lead to injuries. Neverthelss, the richest opportunity for improvement lies in reducing the likelihood of occurence of the failure.

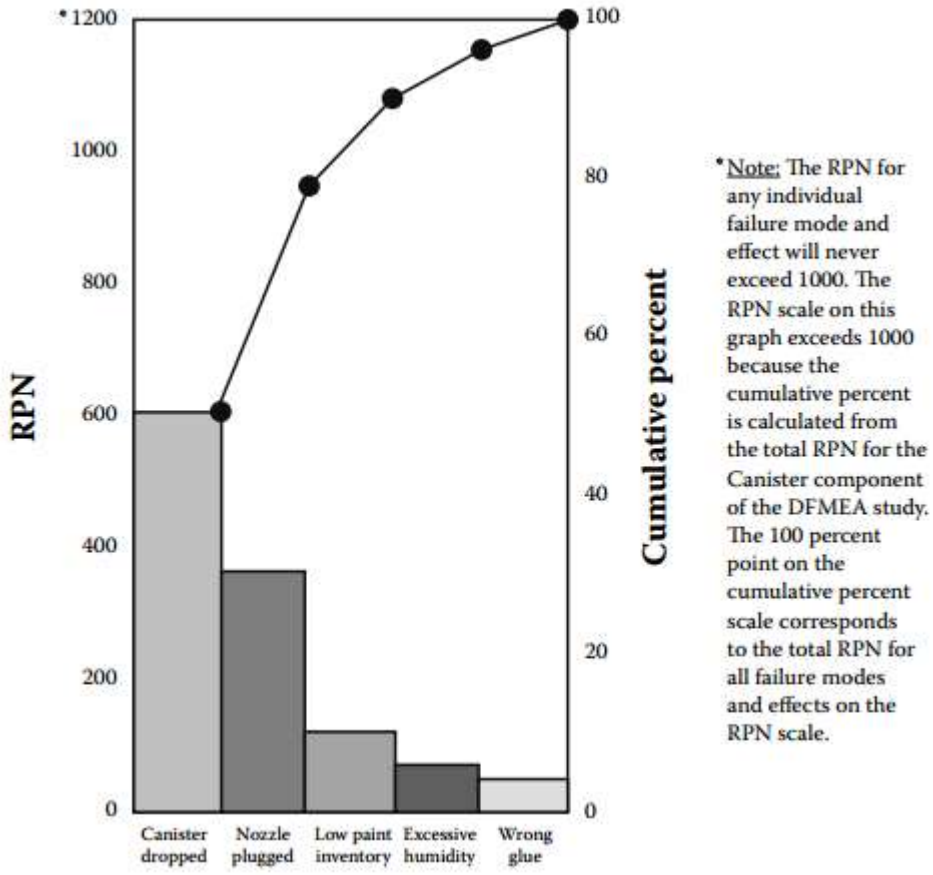


Figure 2. 3 Example of Pareto Diagrams of Ranking
Source (McDermott, et al., 2009)

Table 2. 9 Specific Actions to Reduce Rankings

Severity	Occurence	Detection
• Personal protective equipment (e.g., hardhats or bump caps, side shields on safety glasses, full face protection, cut-proof gloves, long gloves) • Safety stops/emergency shut-offs • Use different material, such as safety glass that will not cause as severe an injury should it fail.	• Increasing the Cpk through design of experiments and/or equipment modifications. • Focus on continuous improvement/problem-solving teams. • Engaging mechanism that must be activated for the product or process work (e.g., some lawn mowers have handles that must be squeezed in order for them to operate).	• Statistical process control (to monitor the process and identify when the process is going out • of control) • Ensure the measuring devices are accurate and regularly • calibrated. • Institute preventive maintenance to detect problems • before they occur. • Use coding such as colors and shapes to alert the user or worker that something is either right or wrong.

Source: McDermott, et al. 2009

h. Calculate The Resulting RPN as The Failure Modes are Reduced or Eliminated

Once action has been taken to improve the process, new rankings for severity, occurence, and detection should be determined, resulting new RPN calculated. The resulting RPNs can be rganized on a Pareto diagram and compared with the original RPNs. The total RPNs of the before-and-after process also can be compared.

2.5.3 Advantages and Disadvantages of FMECA

As useful as FMECA method is, of course it has several advantages and disadvantages, too. According to Hodge (2014), FMECA is a logical, structured way to identify areas of concern while reducing time and cost. It is also an effective way to improve areas in which the performance are not great. Moreover, FMECA methods is able to early identification of single failure points and system problems that can hinder success and impact safety.

However, how good and complete the FMECA results are depending on the team behind it. Moreover, if one failure modes are forgotten to be listed, there is a high chance the risk will be ignored.

Another limitaiton is a function of FMECA's bases for prioritizing failures modes according to their risk. This will not eliminate the failure modes, thus further actions must be taken. FMECA also must be regularly updated as new potential falure modes may appear.

2.6 Decision-making Trial and Evaluation Laboratory (DEMATEL)

According to Wei and Gwo-Hsiung (2009), DEMATEL method is a methodology which can be used for researching and solving complicated and intertwined problem groups. The end product of theDEMATEL process is a visual representation—the impact-relations map—by which respondents organize their own actions in the world.

The DEMATEL method not only change the relationship between cause and effect from criteria to structural model, but also can be used as a way to handle dependence (inner dependence) in a set of criteria. DEMATEL is very popular in Japan as it is a comprehensive method for building and analyzing structural models involving causal relationships between complex factors. DEMATEL is based on digraphs that can split between causal and cause groups. Digraf is widely used because digraphs can show relationships of sub-systems. In addition, digraphs illustrate the basic concepts of contextual relationships between elements

of the system, where the numbers indicate the forces of influence from one element to another.

According to Wu (2008), there are five main steps in the implementation of DEMATEL.

2.6.1 Make Direct Relationship Matrix

First, the relationship of each criteria is calculated using comparation scale with 4 level of effect: 0 (no relationship); 1 (low relationship); 2 (medium relationship); 3 (high relationship); and 4 (very high relationship). Then, author will create set of comparison about relationship of each criteria. As the result of the evaluation, the direct relationship matrix can be seen, n × n matrix A, where aij means how criteria i affect criteria j.

2.6.2 Direct Relationship Matrix Normalization

Based on the direct relationship matrix A, the normalization of matrix X direct relationship can be calculated by the equation below.

$$X = k \times A \tag{2.2}$$

$$k = \frac{1}{\underset{1 \le i \le n}{Max} \sum j=1 aij} \, i, j = 1,2, \dots, n \tag{2.3}$$

Where,

X : Normalization Matrix

A : Direct Relationship Matrix

k : konstanta

2.6.3 Generate Total Relationship Matrix

After the normalizaton of matrix X relationship is calculated, total relationship matrix T, signed as identity matrix, can be calculated using the equation below.

$$T = X\,(1 - X)^{-1} \tag{2.4}$$

Where,

T : Total relatrelationship matrix

2.6.4 Calculate Vector D (dispatcher) and Vector R (receiver)

The number of rows and number of columns separately is denoted as vector D and vector R. Then, horizontal vector (D + R) called "Prominence" is created with adds D to R, which expresses how important those criteria are. Similarly, the vertical axis (D - R) called "Relation" is created with subtract D from R, which can divide criteria into groups cause and group effect. Generally, when (D - R) is positive, these criteria are the causative group. Conversely, if (D - R) is negative, the criterion is a result group.

$$T = [tij]_{n\times n} i, j = 1,2, \dots, n \quad (2.5)$$

$$D = [\sum_{j=1}^{n} tij]_{n\times 1} = [ti]_{n\times 1} \quad (2.6)$$

$$R = [\sum_{j=1}^{n} tij]_{1\times n} = [tj]_{n\times 1} \quad (2.7)$$

Where,

D : Discpatcher vector

R : Receiver vector

Vector D and R show the number of rows and columns from the matrix T relationship.

2.6.5 Create Impact Digraph Map

Based on the relationship matrix in total, each value gives information how much influence the group of criteria i against the criteria group j. If all values are converted to an impact-digraph map, then the structure will be too complex to get information for decision makers. Therefore, a threshold value for the level of influence is required. Only some elements that have greater than the threshold value of the T matrix can be selected and converted in impact-digraph maps. The threshold value is determined by decision making or from an expert person by conducting a discussion. Impact-digraph maps can be obtained by mapping data sets from (D + R, D - R), so they can provide information to make decisions.

3.1 Previous Research

In determining the objectives and method of this research, studies on previous research is conducted. There are several existing researches that can be used as consideration for developing the method and approach. Table 2.8 shows the review of previous researches

related to the similar field of studies.

Table 2. 10 Previous Research

No	Author	Type	Title	Method
1	Almira Hasna Z. (2017)	Bachelor Degree Research	*Analisis Risiko Pada Aktivitas Proses Bisnis Instalasi Farmasi Rumah Sakit Islam Jemursari Surabaya Dengan Menggunakan Metode Failure Mode, Effect, And Criticality Analysis (FMECA)*	FMECA
2	Meynar Khairunisa (2011)	Bachelor Degree Research	*Identifikan Profil Risiko Unit Pelaksana Area PT PLN (Persero) Distribusi Bali menggunakan Pendekatan FMECA*	FMECA
3	Bima Surya Sofhananda (2016)	Bachelor Degree Research	*Implementasi Metode Delphi dan Quality Function Deployment untuk Perancangan Evaluasi Berbasis Green Building Standard*	Delphi, QFD
4	Laliya Rohmana (2016)	Bachelor Degree Research	*Analisis Kebutuhan Jumlah Blok Twin-Automated Stacking Crane dengan Mempertimbangkan Turnaround Time Kapal pada Terminal Teluk Lamong melalui Pendekatan Simulasi*	Discrete Event Simulation
5	Skumolski and Hartman (2007)	Journal	*The Delphi Method for Graduate Research*	Delphi
6	Lipol and Haq (2011)	Journal	Risk analysis method: FMEA/FMECA in the organizations.	FMECA

CHAPTER 3
RESEARCH METHODOLOGY

This chapter shows methodology used in the research, consists of steps in order to solve the problem. These steps will be the guide for the author to resolve the research, systematically thus the goals of the research could be achieved.

3.1 Problem Identification and Formulation Stage

In Problem Identification and Formulation Stage, the process of the stage will be elaborated, consists of existing condition idenfitication of risk management related to ASC in Terminal Teluk Lamong, problem formulation, research purposes and benefits determination, research scope, literature review, and field study.

3.1.1 Existing Condition Identification of Risk Management Related to ASC in Terminal Teluk Lamong

In this stage, personal interview and observation are done with ASC operators and staff of QHSSE of Terminal Teluk Lamong as stakeholders related directly to ASC. The process of working related to ASC, the standard procedures, accidents data, and behavior in the ASC is known.

3.1.2 Problem Formulation and Research Purposes, Benefis, and Research Scope Determination

After the problem and the source is known, then the problem formulation is conducted follows by the solution for the poblem. After then, the purposes of research and benefits to parties related are detemined. For the research scope, the limitation and assumptions of the research are done based on literature review and field study.

3.1.3 Literature Review

In this step, author collects the references needed as a guide to solve existing problem. The source of literature review are journals, books, and previous research that is related to the existing problem. Literature review consists of theories and methods that is being used in this research by the author. The literature study of this research are Risk, Risk Management, Green Port, Dephi Method, and Failue Modes, Effect, and Criticalily Analysis (FMECA).

3.1.4 Field Study

Field study is done to know the existing condition of risk management in Terminal Teluk Lamong.

3.2 Data Collection Stage

In this stage, author collects data and identify operational activities related to ASC Terminal Teluk Lamong. Then, the risks will be identified using Delphi Method, and assess risk using FMECA method (RPN questionnaire).

3.2.1 Data Collection

The data needed by author will be collected. The data that is needed are document of operational risk management and document of risk event related to Automated Stacking Crane.

3.2.2 Operational Activitites Identification

To identify the operational activities related to Automated Stacking Crane, observation and personal interview will be conducted to the stakeholder related directy to its operational activities and risk agent of Terminal Teluk Lamong. The stakeholder is the risk agent and risk owner of Terminal Teluk Lamong.

3.2.3 Identify Potential Risk with Delphi Method

In this step, the potetial risk will be identified using Delphi Method. Questionnaire will be given to stakeholder related directly to its operational activities and the higher-ups of Terminal Teluk Lamong work shop.

3.2.4 Assess Risk with FMECA Method

In this step, the assessment of identified risk will be done using questionnaire. The assessment will be done using Failure Mode, Effect, and Criticality Analysis (FMECA). By using this method, the risk will be scored based on three indicators: Potential Effect (Severity), Risk Cause (Occurence), and Current Control (Detection). Each indicator will be scored based on the previous failure related to ASC. The, the assessment will be done by questionnaire to related stakeholder of ASC.

3.2.5 Assess Risk Relationship with DEMATEL Method

In this step, the assessment of risk relationship will be done using DEMATEL method. By using method, a risk will be scored based on the level influence to another risk. The assessment based on the questionnaire towards related parties of ASC at Terminal Teluk Lamong. The output of this step is impact-diagraph map.

3.3 Data Processing Stage

After all of data required is collected, data is processed to several results, namely as follows.

3.3.1 Risk Evaluation

In this step the questionnaire result will be procssed to know the risk matrix and listing identified risk related to ASC at Terminal Teluk Lamong. By calculate Severity, Occurrence, and Detection from the questionnaire, the risk priority number (RPN) can be known and the level of each risks can be determined.

3.3.2 Risk Mitigation

In this step, the strategy to handle the risk will be developed. The action towards the risk is also determined. Thus, Terminal Teluk Lamong knows how to mitigate the risk and, if happened, knows how to handle any accident related to ASC.

3.4 Analysis and Interpretation Stage

In this step, the analysis based on data processing will be done. It consists of analysis of risk management implementation, analysis of operational activities related to ASC, analysis of risk identification and risk assessment, analysis of strategy formulation to handle risk of ASC, and analysis of dashboard design for risk profile using Microsoft Excel.

3.5 Conclusion and Recommendation Stage

In this steps, the formulation of conclusion and suggestion to related parties will be done based on the result of data analysis and interpretation. The conclusion will answer research purposes and suggestion is formed towards the object, in this case Terminal Teluk Lamong.

3.6 Research Flowchart

Flowchart will show the flow of the this research process. Below is the flowchart for this research.

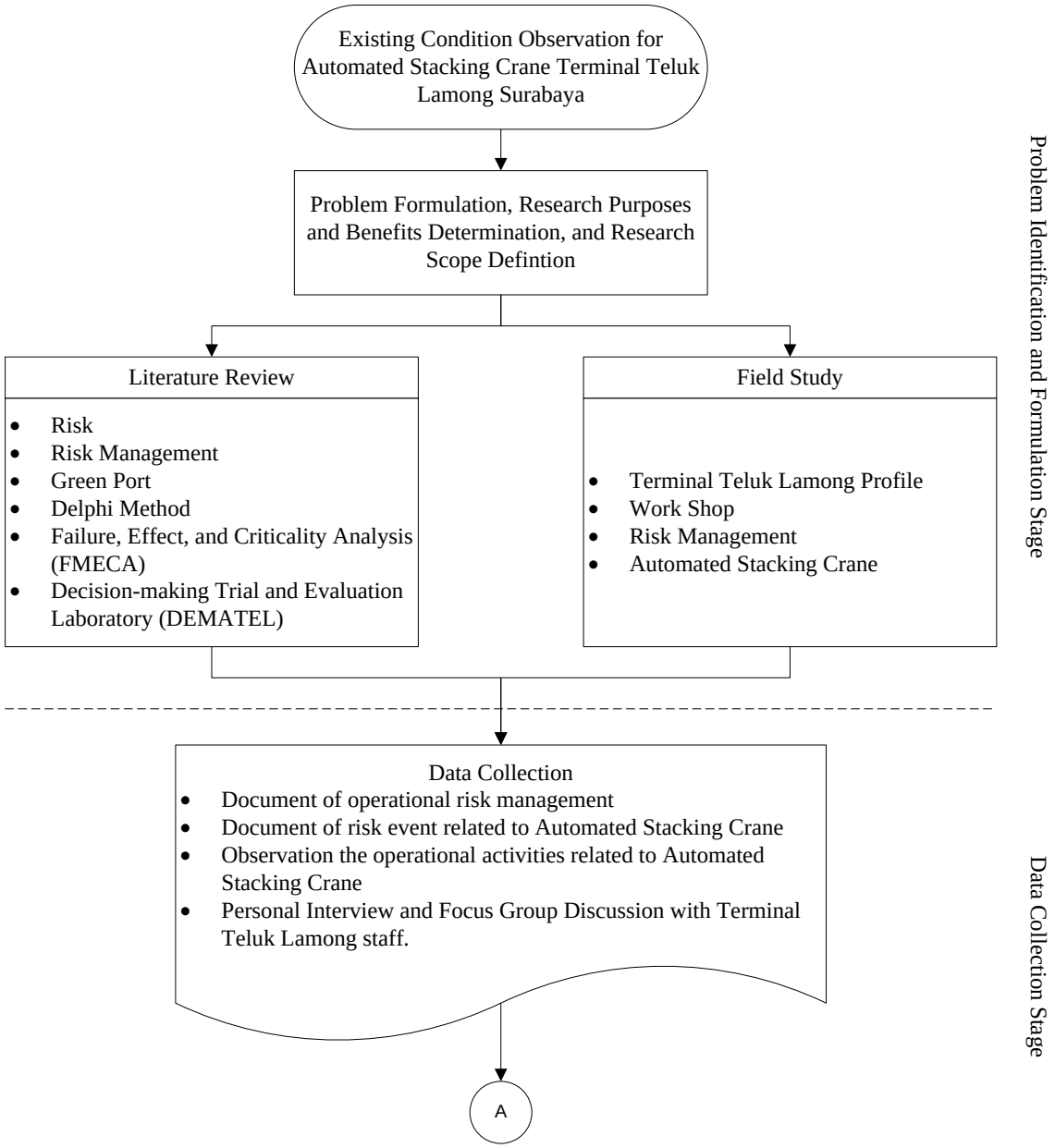


Figure 3. 1 Flowchart of Research

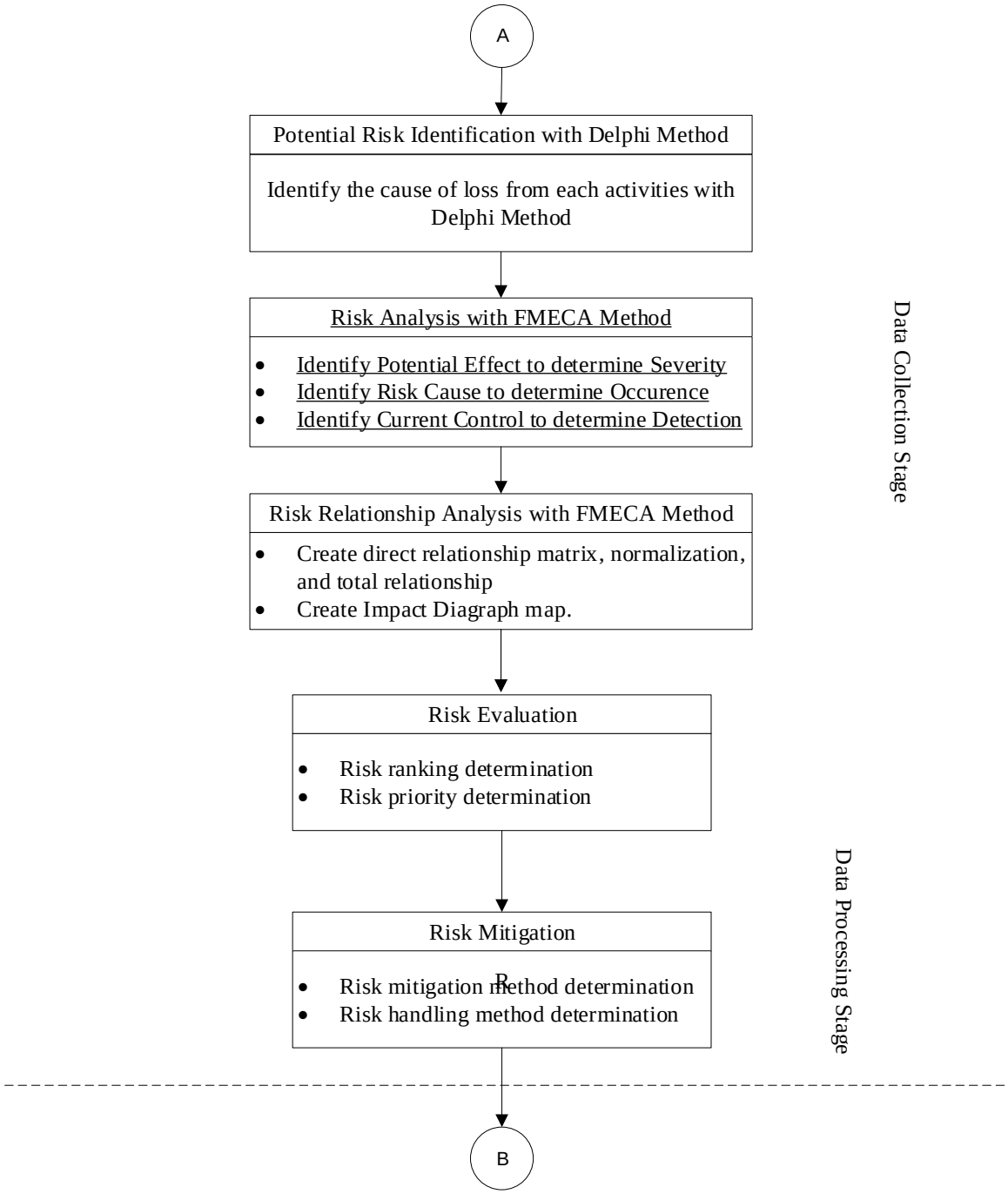


Figure 3. 2 Flowchart of Research (con't)

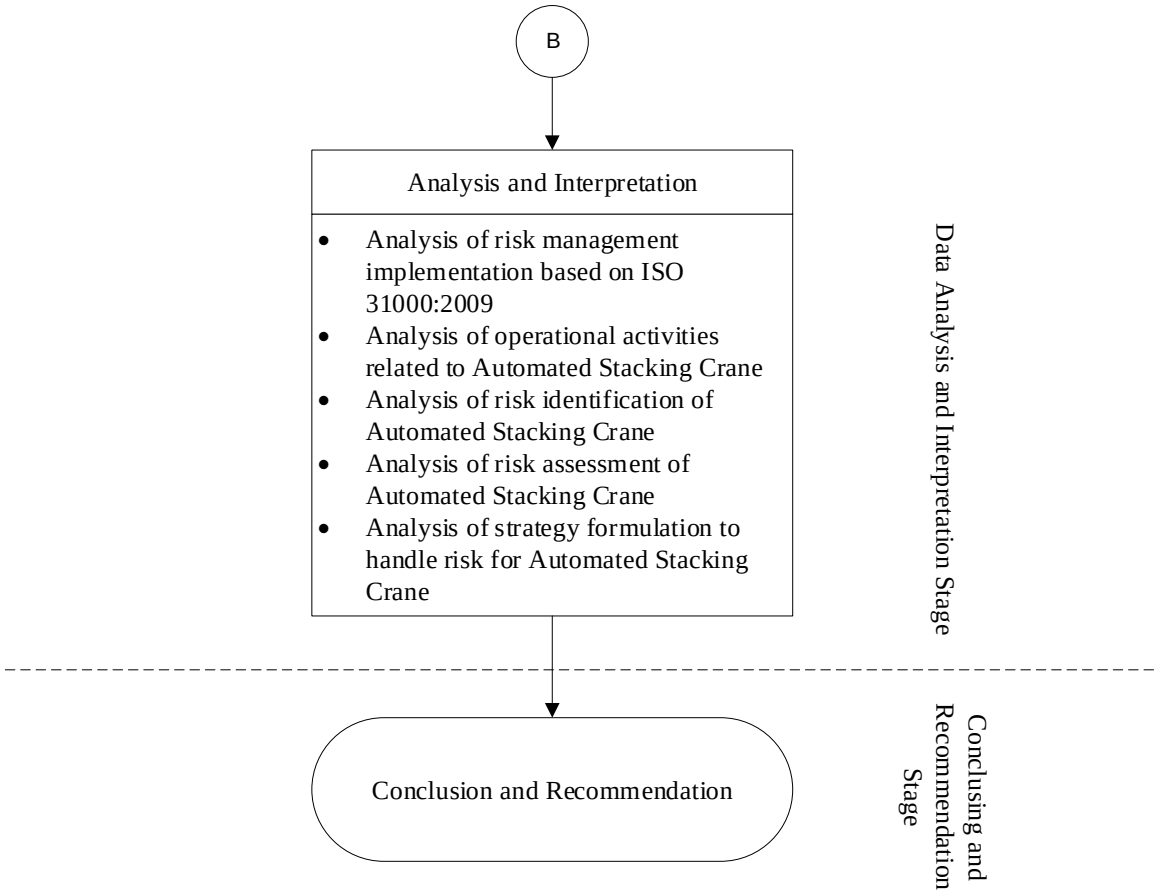


Figure 3. 3 Flowchart of Research (con't)

CHAPTER 4
DATA COLLECTING AND PROCESSING

This chapter shows the result of data collecting from the operation process of Automatic Stacking Crane at Terminal Teluk Lamong. Later, the data will be processed into risk evaluation, risk mitigation, and risk profile dashboard design.

4.1 Profile of Terminal Teluk Lamong

PT Terminal Teluk Lamong is subsidiary company of PT Pelabuhan Indonesia III (Persero), built as a development of Tanjung Perak Port. Inaugurated in 2 May 2015, it is equpped with advanced loading and unloading technology. It is located at Jln. Raya Tambak Osowilangun KM 12, Surabaya, Indonesia.

Terminal Teluk Lamong is built as an effort to support the flow of goods from and the territory of eastern Indonesia to anticipate the increasing of containers traffic and bulk as a result of global market in the Port of Tanjung Perak and to avoid stagnation in Port of Tanjung Perak.

Figure 4. 1 The Warft Condition of PT Terminal Teluk Lamong
Source: Author's Document

The vision of Terminal Teluk Lamong is “to be on the best five Eco-Friendly operator terminal in South-East Asia in 2020”. Terminal Teluk Lamong is established as green port. That is why, all of the process inside are in accordance to the environmental aspects.

By now, the development of Terminal Teluk Lamong is not yet completed. It is planned at year 2030, Terminal Teluk Lamong will perfect their facilities including industrial area, dry bulk area, waste and water management, power plant, SPBG, fly over, broad band, and monorail.

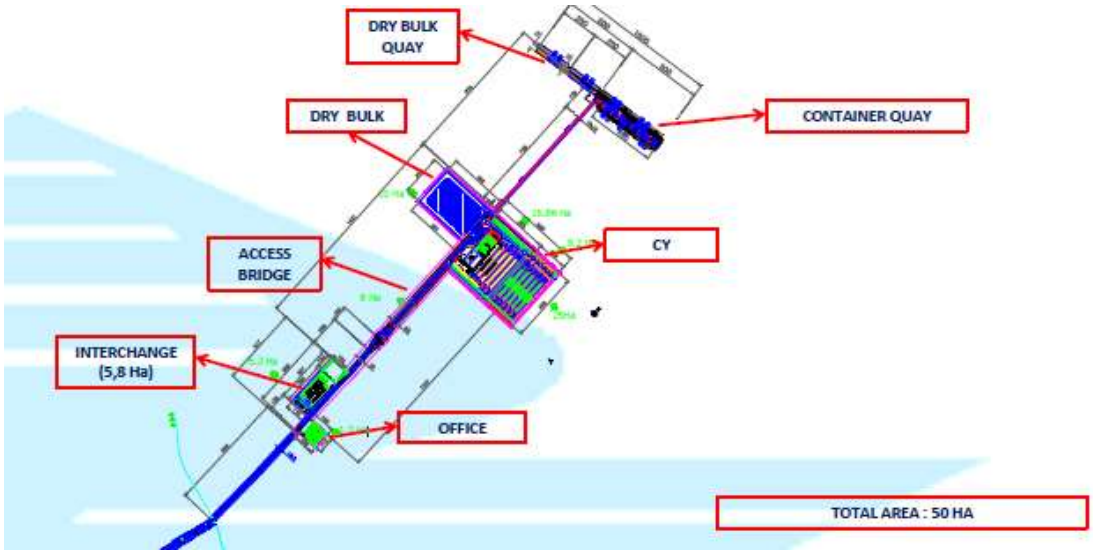


Figure 4. 2 Layout of Terminal Teluk Lamong year 2018
Source: Company’s document

For the marketing and communication with customer, Terminal Teluk Lamong use Electronic Data Interchange Format. Amongst Terminal Teluk Lamong as port, agent/shipping line, container depo, bank, trucking company, customs, and forwarder, the information exchanges are done via Terminal Teluk Lamong server. It is done to eliminate any illegal activities thay may occur if all parties meet up face to face.

For now, the handling for domestics is up too 342.000 TEUs, whilst for international wharf is up to 435.000 TEUs. In the facilities, the warft have two sides, international side (500 × 50)m^2 14 m LWS depth and domestic side (450 × 30) m^2 10 m LWS depth, 15,86 Ha container yard, 8.000 tonnes dry bluk storage, and container freight station. For the equipments, Terminal Teluk Lamong does not use manual equipments anymore. For example, in the warf, Terminal Teluk Lamong use Ship to Shore (STS) crane. They also purchase Combined Terminal Trailer (CTT), Automated Stacking Crane (ASC), Reach Stacker (RS), Straddle Carrier (SC), Gas Truck, Conveyor, and GSU.

Terminal Teluk Lamong is still developing their wharft. As you can see in Figure 4.3, international wharft is longer and deeper than domestic wharft. This is due to the fact that international ship is usually much bigger than domestic ship. Later, they will lengthen and deepened the wharft so that more ship may come to Terminal Teluk Lamong.

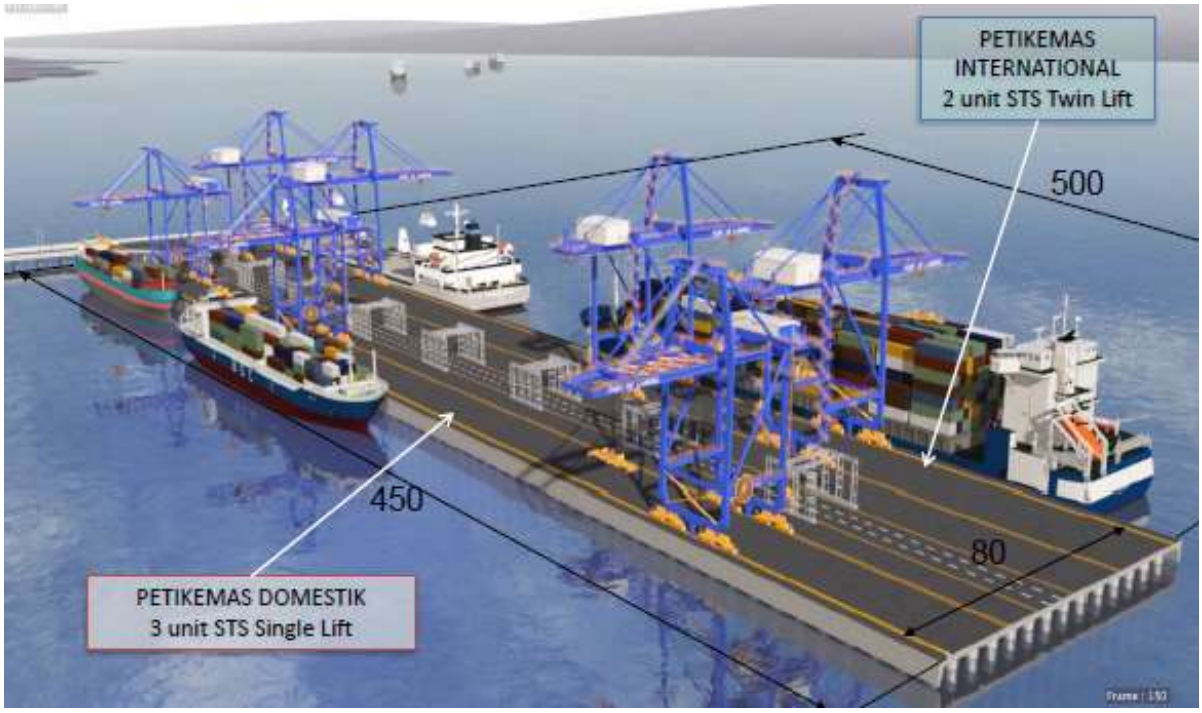


Figure 4. 3 Terminal Teluk Lamong Wharft
Source: Company's document

As for their container yard, it is used to store containers from both domestic and international ship. Their container yard can also contain reefer, which is a cold storage in the form of container. As per year 2018, there are in total 10 blocks of container yard. Each block is equipped with 2 automatic stacking crane. 5 blocks belong to the domestic containers, whilst the other for international container. All of the container movement is monitored via control room in workshop building, near container yard.

Terminal Teluk Lamong also has container freight station (CFS). This is the station where any parties want to check, repair, or re-calculate the condition and weight of the container.

To relocate the container from ship to the container yard: first, STS will place the container to CTT. Then, the CTT will be driven to the WSTA, where the container will be dumped and picked up by ASC to container yard. When it is time, the container yard will be picked up again by ASC to the truck where it belongs.

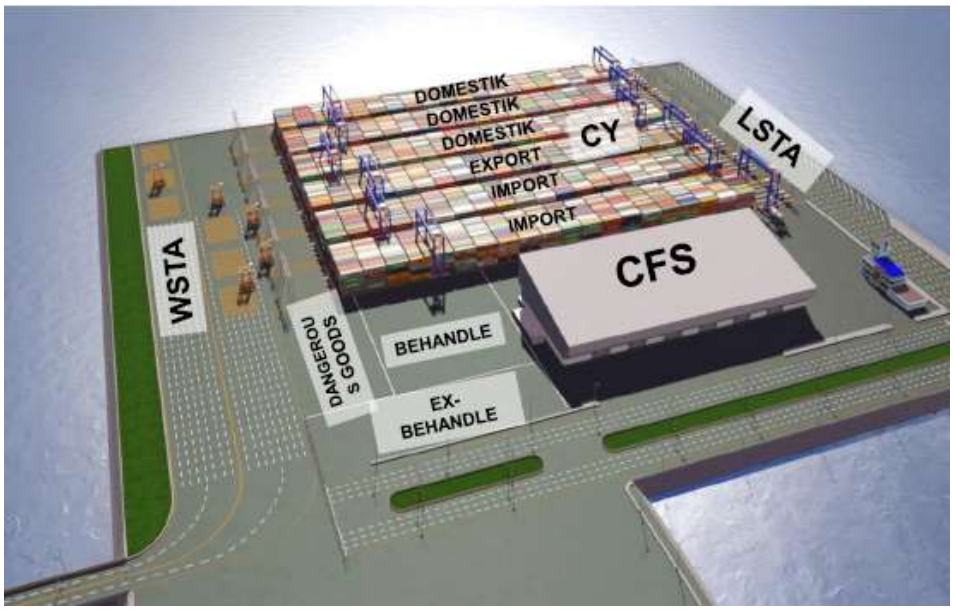


Figure 4. 4 Terminal Teluk Lamong Container Yard
Source: Company's document

Terminal Teluk Lamong only serve container that fulfill ISO technical requirements. It means, Terminal Teluk Lamong serve for 20-feet container, 40-feet container, 40-feet-high-cube container, and 45-feet-high-cube container.

Actually, Terminal Teluk Lamong not only serve container in their business, but also dry bulk, specifically for food and feed. From the wharft, the bulk will be transferred to dry bulk storage using conveyor. There are 10 silos that is owned by Terminal Teluk Lamong. For the process, Terminal Teluk Lamong established an agreement with PT Nusa Prima Logistik.

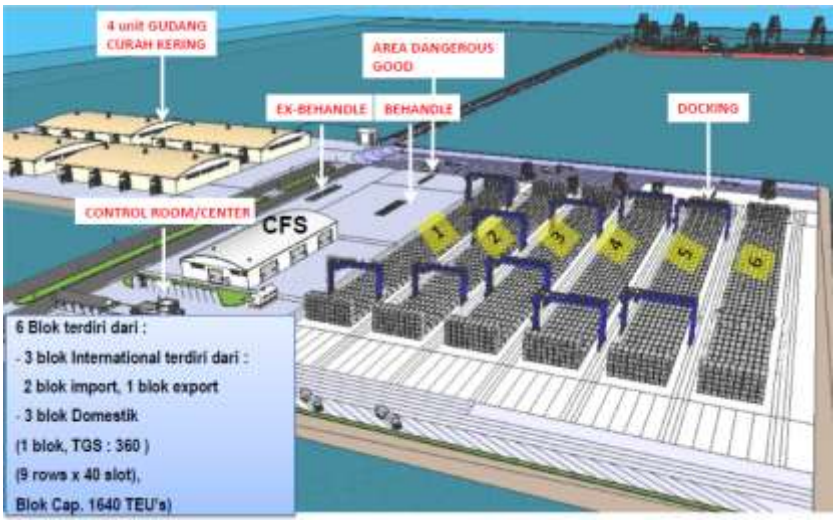


Figure 4. 5 Terminal Teluk Lamong Container Yard and Supporting Facilities
Source: Company's document

4.1.1 Vision and Mision of Terminal Teluk Lamong

PT Terminal Teluk Lamong has established their vision and mission as their foundation in the process. The vision of PT Terminal Teluk Lamong is as follows.

Vision

"To be on the best five eco-friendly operator terminal in South-East Asia in 2020"

To achiever their vision, PT Terminal Teluk Lamong has several missions as follows.

Mision

1. To provide integrated terminal services in the shipping industry based on the SLA, SLG, and international standards/regulations.
2. To ensure profit growth/company development by using efficient and innovative terminal management with eco-friendly cutting edge technologies.
3. To produce competent employees with high-quality performance through development and welfare.

4.1.2 Organization Structure

The organization structure at PT Terminal Teluk Lamong follows the functional type, which means a department is formed based on the similarity of job description and field. The organization structure at PT Terminal Teluk Lamong can be seen below.

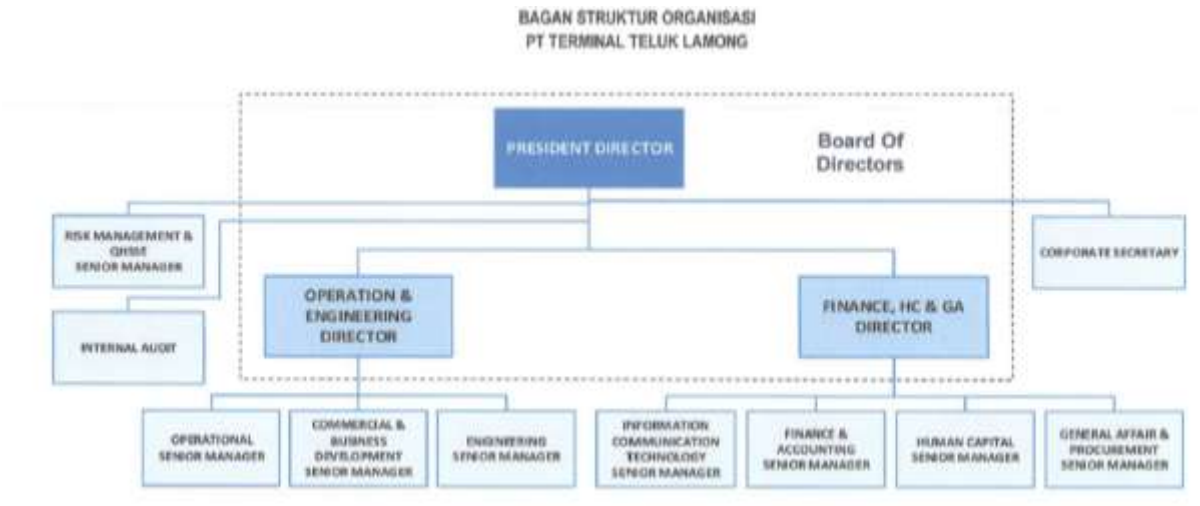


Figure 4. 6 Organization Structure of Terminal Teluk Lamong
Source: Company's document

4.2 General Description of Automatic Stacking Crane

Automatic Stacking Crane is one of the equipment that makes Terminal Teluk Lamong differs from other port. It is the only one in Indonesia, operates with electricity, with less operators and semi-automatic system, just like the name states.

So, what is actually automatic stacking crane? It is defined by Terminal Teluk Lamong as an equipment to lift and transport container, from truck to container yard, or the other way around, automatically.

Figure 4. 7 Automatic Stacking Crane at Terminal Teluk Lamong
Source: Company's document

With automatic stacking cranes, the whole cycle from pick-up to set down of a container, including road truck handling, is fully automatic. Therefore, each remote operatore can supervise a large number of cranes, and the automated cycle allows the operator to perform additional tasks simultaneously.

The use of ASC has several advantages. First, higher effectiveness and efficiency of port activities as less operators and administrator needed. Second, eco-friendly equipment because it uses electricity, thus there is less air pollution, noise pollution, and vibration. Third, stable productivity since it is capable to work 24 hours a day. And last, paperless, since all of the administration activities are done via IT system, so that reduce the meetings between customer and employees, and minimize the occurrence of authority abuse

Automatic Stacking Crane is placed in the container yard. Container yard is the port facilities at which container are accepted for loading onboard ships and off-loaded containers are delivered to customers.

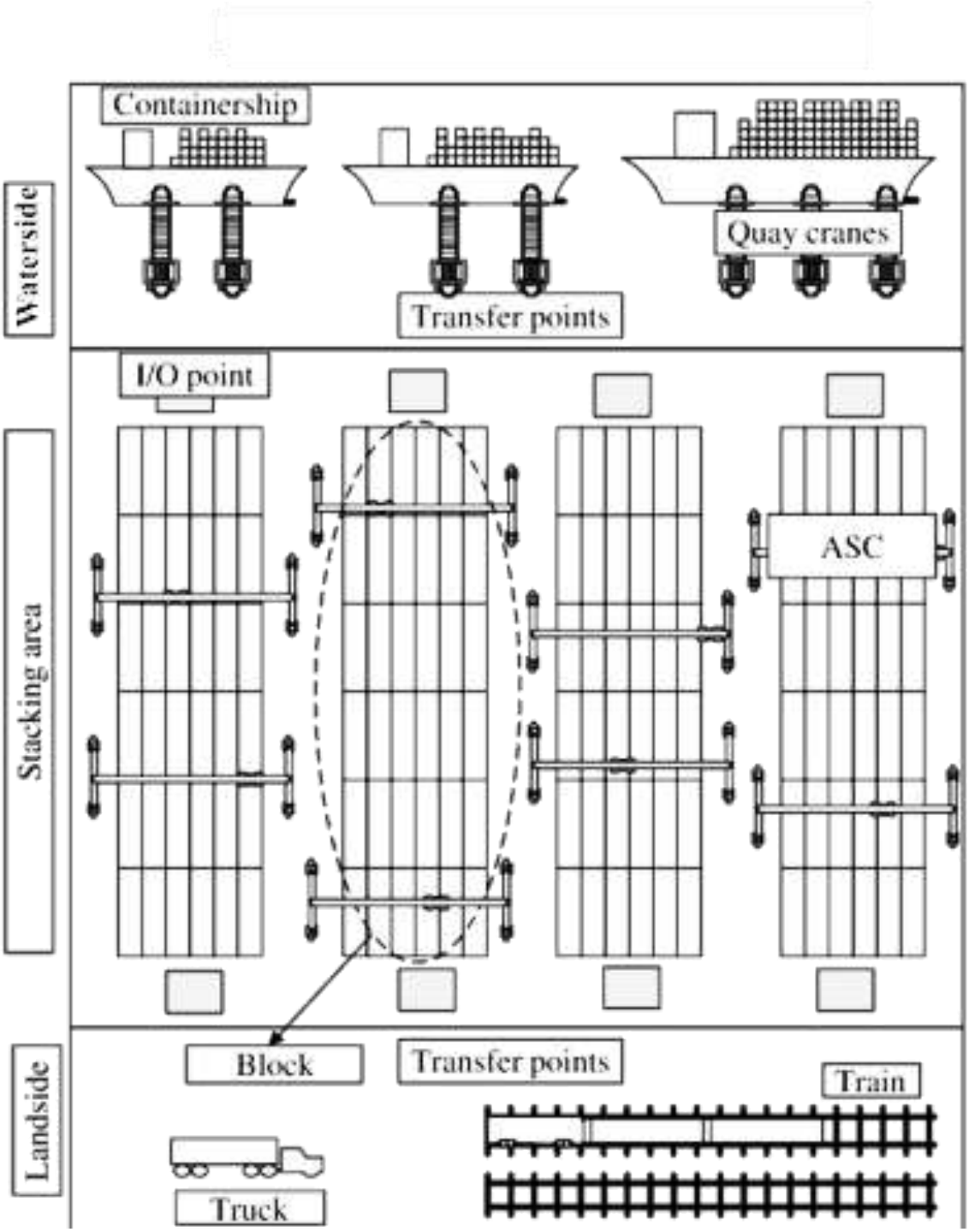


Figure 4. 8 Top View of General Container Yard
Source : Gharegozli, et al (2014)

There are total three areas in the container yard: landside, stacking area, and waterside area. Landside is the location at which container movement from the truck to the stacking area is happened. In landside, trucks will queue to get their container to the stacking area. After that, trucks enter the booth where it is a part of Automatic Stacking Crane. Then, the container will be lift on/off, depend on the needs of trucsk to give or take the container.

Stacking area is where the container is stacked. After the container is lifted, the Automatic Stacking Crane is moving to find a place the container to be put in. In Terminal Teluk Lamong, the maximum number of tier for a container to be stacked is five tiers.

Waterside area is the location at which container movement from the sea to the stacking area is happened. In the waterside, CTT will be used to move the container from/tp wharft. When requested, Automatic Stacking Crane will bring the container to the transfer point. Then, the CTT will pick it up. Or, the CTT will put the container in the transfer point, then the Automatic Stacking Crane will pick it up.

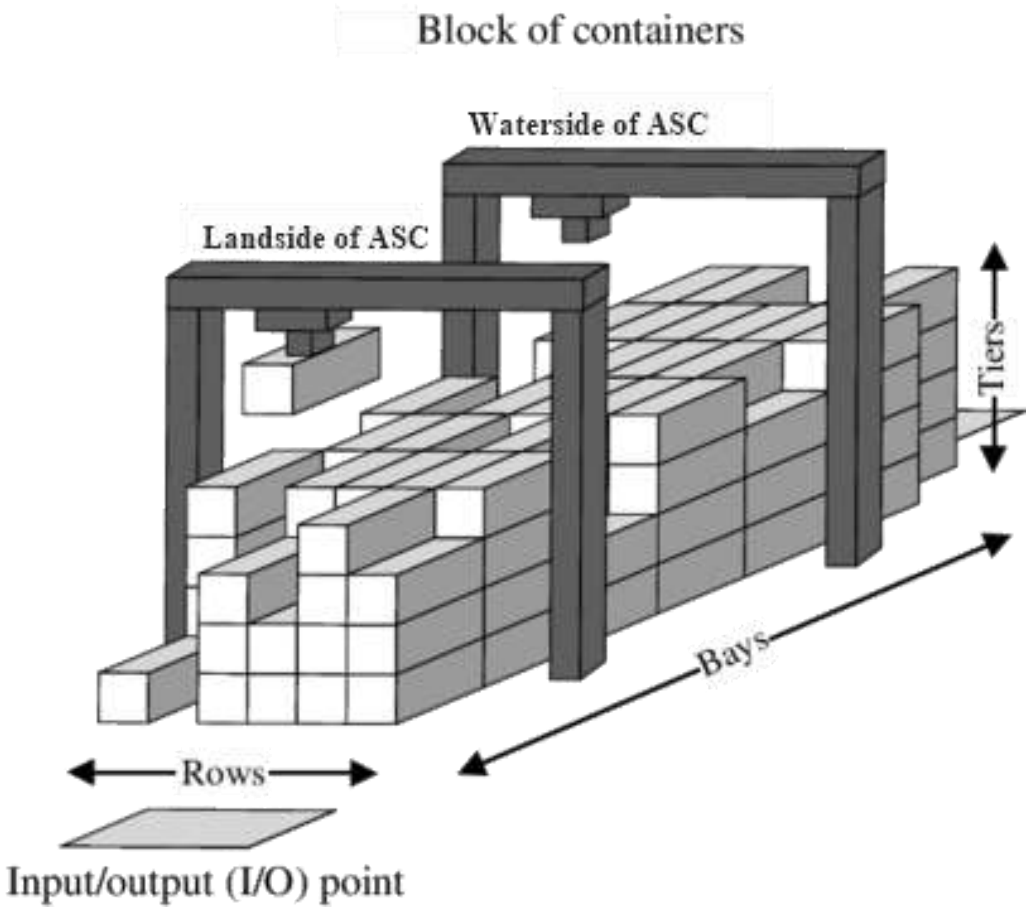


Figure 4. 9 ISO View of General Container Yard
Source : Gharegozli, et al (2014)

4.3 Risk Management for Automatic Stacking Crane

Terminal Teluk Lamong is already implementing ISO 31000 : 2009 in their corporate risk management. They have several risk management for automatic stacking as shown in the table below. However, a well-established risk management for automatic stacking crane is not developed yet.

Table 4. 1 Existing risk management of Automatic Stacking Crane

Facilities	Potential Failure Mode	Potential Effects(s) of Failure	Potential Cause(s) of Failure	Severity	Occurences	RPN	Exposure	Recommended Action	Severity	Occurences	RPN	Exposure
Container Yard	ASC failed to work	Container handling operation time suffered	System/ equipment down	3	3	9	High	Scheduled maintenance	2	1	2	Low
	Wrong stacking	Damaged container	Incompatibility planning	4	3	12	High	Training operator, automation application, scheduled system evaluation	4	1	4	Medium
	Accident	Employee safety	Human Error	5	3	15	High	Training, automation application	2	1	2	Low
	Power outage	Stack process delayed	External source of electricity, supplier risk	3	4	12	High	Provide alternative energy source	2	2	4	Medium
	System error	Stack process delayed	System down	2	3	6	High	Scheduled system control	1	2	2	Low
	Container fall off of ASC	Financial loss	Human Error	4	3	12	High	Training, performance evaluation	3	2	6	High

Source: Author's document

From Table 4.1, it can be seen that the risk management for Automatic Stacking Crane is not yet complete. The risk management is focus on the events of integrated system, yet the potential failure mode specific to Automatic Stacking Crane is not listed. Besides, the risk owner of Automatic Stacking Crane is not mentioned.

In Terminal Teluk Lamong, Risk Agent is a term for the employee in a work unit that has a responsibility as person in charge to ensure the risk management is working well in the company. Risk Owner is a term for the employee that exposed directly to a risk.

4.4 Operation Process Identification of Automatic Stacking Crane

To know the risk related to Automatic Stacking Crane, first the operation processes related to Automatic Stacking Crane are needed to be identified. The flowchart that is served in this subchapter is simplified from all of the system procedure Terminal Teluk Lamong publishes in their business to the research needs. The operation will be divided into: Planner, CTT, Truck, and Maintenance.

4.4.1 Operation Process Identification for Planner

Before a container enters container yard, it is a planner duty to know if a slot is available for the container to sit in. Planner is the party that decide at what slot the container will be placed, at what time, and for how long. This detail is given by agent/shipping line to the planner, so all they have to do is schedule.

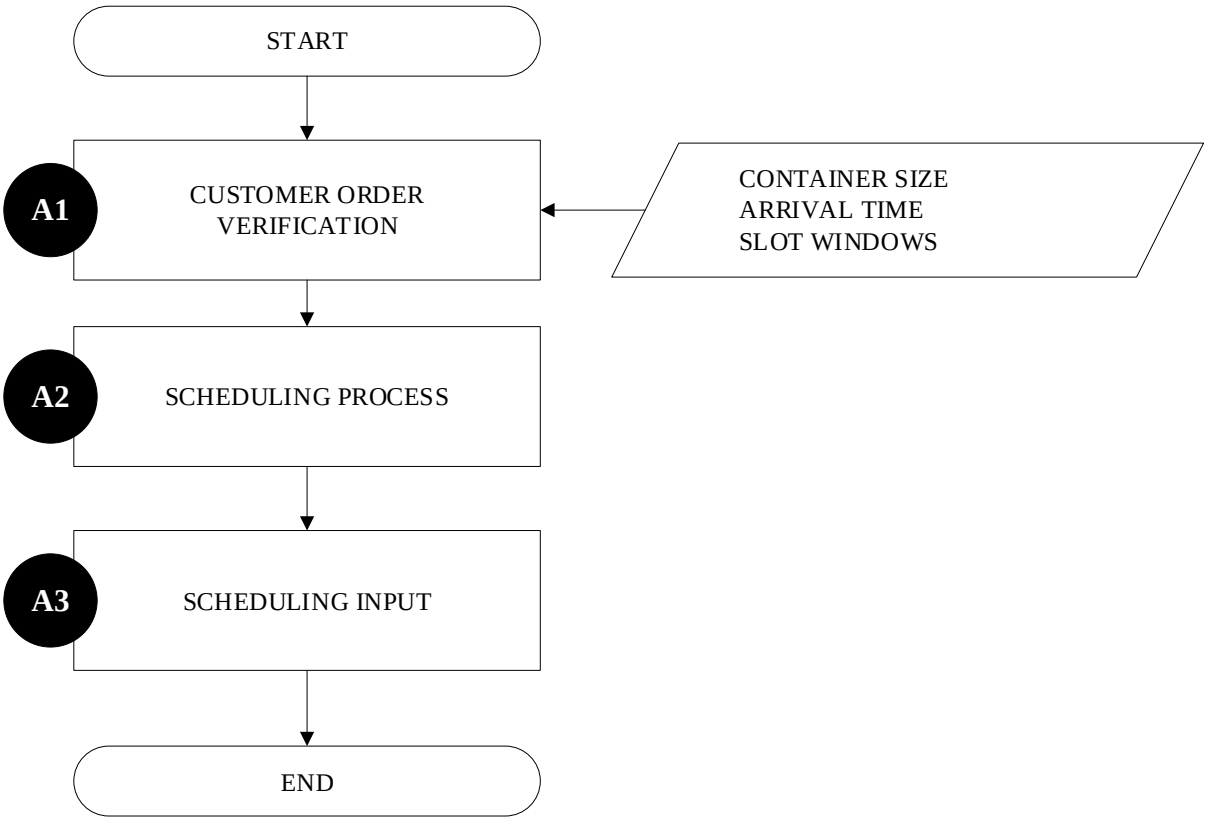


Figure 4. 10 Operation Process for Planner
Source: Author's document

In this process, only planner is taking responsibility. Automatic Stacking Crane operators will work based on the schedule that is set by planner.

4.4.2 Operation Process Identification of Water Side Transfer Area related to Automatic Stacking Crane

A port has container yard. Container yard is functioned as a place where container is stacked before it is being brought to the ship or customer's truck. In the container yard, there are two sides of transfer area. One of them is Water Side Transfer Area (WSTA). The activity brought-picked container from docks to container yard or the other way around is happened at WSTA. To simplify, WSTA is the transfer area in the side of container yard that also side-to-side with the sea, or water.

When a container needs to be moved to the dock/wharft, it is Automatic Stacking Crane operator duty to dump the specified container to WSTA. After it is placed in WSTA, Combined Terminal Trailer will fetch the container and drive it to the dock. It works reversely, too. When a ship is unloading, the container will be brought to the WSTA by Combined Terminal Trailer, which is later picked up by Automatic Stacking Crane.

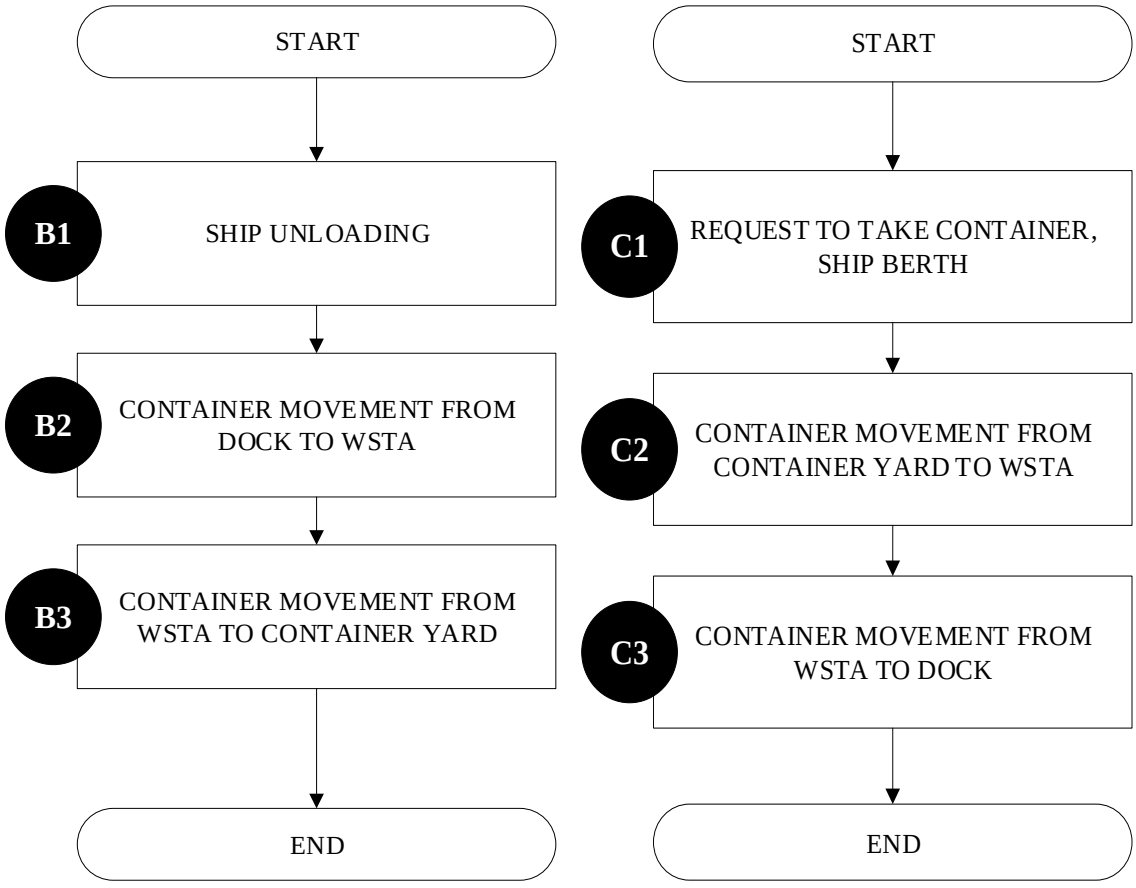


Figure 4. 11 Operation Process a WSTA related to Automatic Stacking Crane
Source: Author's document

4.4.3 Operation Process Identification for Land Side Transfer Area related to Automatic Stacking Crane

Land Side Transfer Area (LSTA) is the opposite of Water Side Transfer Area. It is a place to transfer the container to container yard, but LSTA is side-to-side with land. The activity at Terminal Teluk Lamong LSTA is dominantly using Truck Gas or customer's truck that is certified as green.

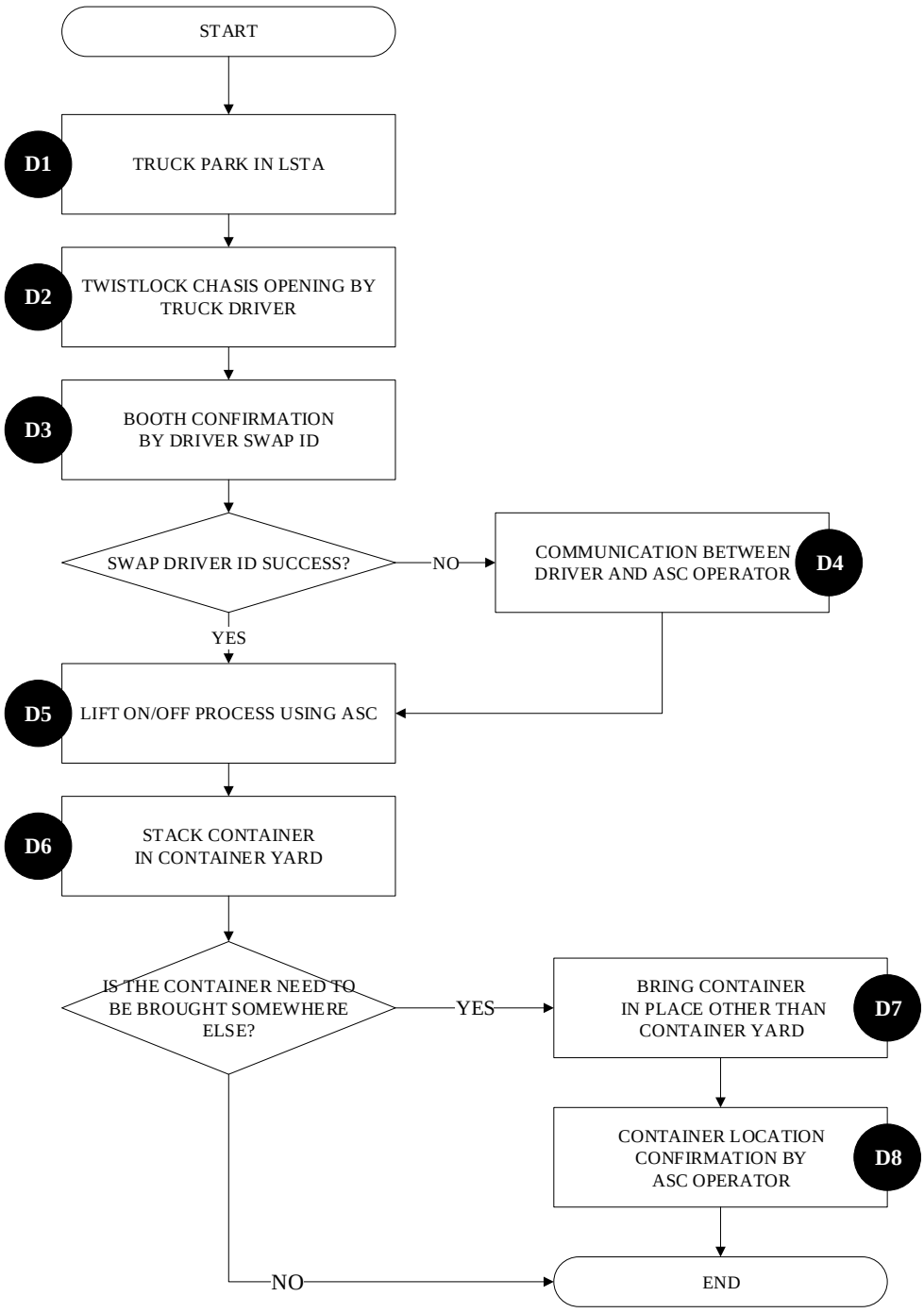


Figure 4. 12 Operation Process a LSTA related to Automatic Stacking Crane
Source: Author's document

4.4.4 Operation Process Identification for Maintenance

For Automatic Stacking Crane, the maintenance schedule is given by the KoneCranes as the distributor of the product. The step and the time span of maintenance is available. There is daily maintenance, weekly maintenance, and monthly maintenance. It is done usually on the spot or the parts is brought to the workshop. Below is the process of Automatic Stacking Crane maintenance activities.

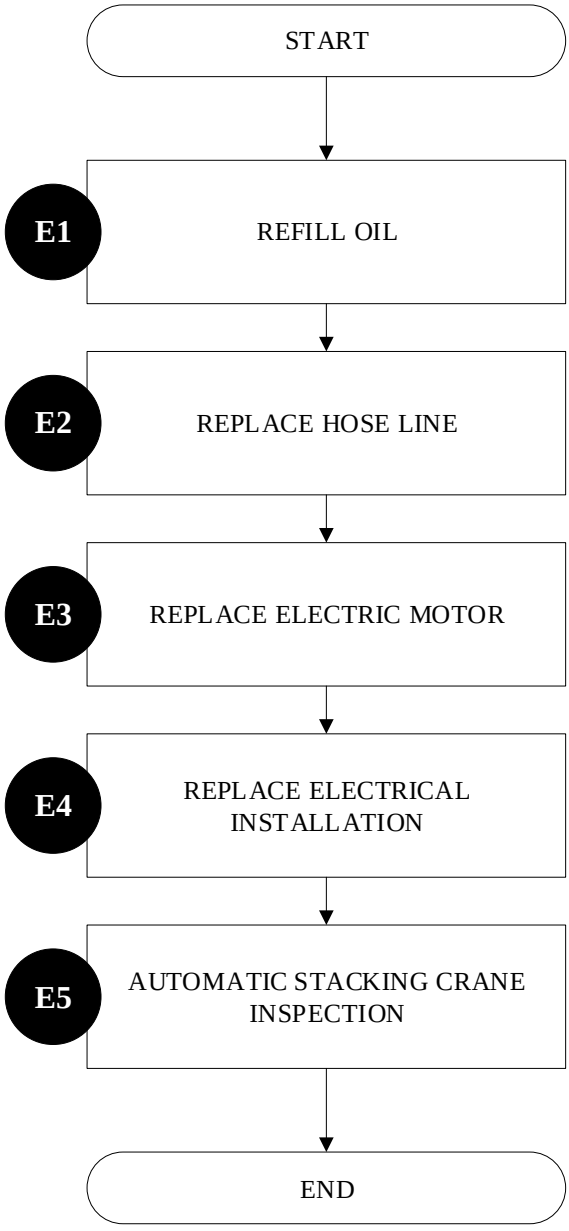


Figure 4. 13 Operation Process of Automatic Stacking Crane Maintenance
Source: Author's document

4.5 Risk Identification using Delphi Method

Risk identification is the first step to establish risk management. In this step, the identification of risk is based on an event that causes an activity to be stopped. If it is, then it can be defined as potential risk. Potential risk could be in the form of an event or a cause of event.

This research will identify risks using Delphi Method. Delphi Method is an analytical method to strengthen brain storm and interview method. To identify risk, several expert respondents that really understand the process of Automatic Stacking Crane Terminal Teluk Lamong are needed. The chosen respondent to identify potential risks are ASC operator, shift manager, planner employee, technical and engineering employee, and QHSSE department.

Below is the sequence of Delphi Method for this research.

1. Form a team to understand the process and establish the risk management. The team is consisted of author, counselor, and the manager of QHSSE department. The author is the practitioner of Delphi Method, in charge of executing the implementation of the method and as a decision maker. The counselor is in charge to supervise and give suggestions to author in the process of Delphi method execution. Manager of QHSSE department is in charge to facilitate author for the data collection and give suggestions as well.
2. Decide the suitable respondents for Delphi method. Since the process is under the workshop area, the data collection is done in the workshop area Terminal Teluk Lamong. After discussion, it is decided to choose 5 people that understand every process related to ASC, which are ASC operator, shift manager, planner employee, technical and engineering employee, and QHSSE department.
3. Explain the objective of the Delphi method and how to fill the questionnaire to identify risk related to ASC.
4. Distribute questionnaire to the respondents. For round 1 questionnaires, the questions are in the form of essays to know the respondents understanding about risk management at Terminal Teluk Lamong and what risk the respondents may identify based on the acitivities listed.
5. Collect and process questionnaires round 1. The result of questionnaires round 1 will be structured and summarize to questionnaire round 2.
6. Create questionnaire round 2 to know whether all of the respondents agree with potential risk listed as result of questoinnaire round 1. To score the agreement

from the respondents, respondents give score using Likert Scale with score indicator 1 – 5.

7. Repeat step 5 and 6 until compromise or consensus from the respondents for the lis of potential risk is achieved. In this research, there are only 2 rounds of Delphi method.

4.5.1 Delphi Questionnaire Round 1

Delphi questionnaire round 1 objective is to get information of respondents profile, whether it match their job and their understanding of risk management implementation in Terminal Teluk Lamong.

Delphi questionnaire round 1 is conducted on 14 – 18 May 2018. Below is the recapitulation of respondents profiles.

Table 4. 2 Respondent of Delphi Questionnaire

No	Position	Starting Year	Education and Expertise
1.	QHSSE Employee	2012	S1 Statistics
2.	Shift Manager	2012	S1 Industrial Engineering
3.	ASC Operator	2014	Engineering High School
4.	Planner	2013	D3 Electrical Engineering
5.	Technical and Engineering	2014	S1 Mechanical Engineering

Source: Author's document

From the questionnaire round 1, it is known that 4 out of 5 respondents is working respectively on their fields. But, they all have working for over 4 years at Terminal Teluk Lamong. Thus, it can be said that the respondents is expert in terms of ASC.

Delphi questionnaire round 1 also has another objective to assess respondents comprehension about risk management in Terminal Teluk Lamong, respectively about its existence, ASC risk management, and risk framework standard used by Terminal Teluk Lamong which is ISO 31000:2009. The result of the questionnaire shows that the respondents do not know about ISO 31000:2009, but they know and implement risk management for their work related to ASC. Although they have not seen any risk management establishment for ASC specifically, the respondents know there are several actions done toprevent any accident happened, such as ASC scheduled maintanance, protective personal equipment use in the area, and warning sign in the container yard.

For Terminal Teluk Lamong, they have done general risk management in order to complete their report of corporate risk management as shown in previous sub chapter, which are automatic stacking crane failed to work, wrong stacking, accident, power outage, system error, and container fall off of ASC.

Then, the respondents identify risk related to ASC based on the activities done related to or around ASC. Below is the risks identified by respondents.

Table 4. 3 Potential risk identified from Delphi Questionnaire round 1 questionnaire

Activity Code	Activity Description	Potential Risk Code	Potential Risk
A1	Customer Order Verification	R1	Unmatch order
		R2	Unmatch goods
		R3	Container is not suitable to the standard
A2	Scheduling process	R4	Trucks tardiness
		R5	System filter is not working
		R6	System filter is not matched with the condition (container size, container types, destination, container weight)
		R7	The system is error
A3	Scheduling input	R8	Wrong input for schedule
B1	Ship Unloading	R9	Damaged tools and equipment
		R10	Careless handling by the employee
B2	Container movement from dock to WSTA	R11	Container cannot enter container yard
		R12	Container is dropped in the wrong block
B3	Lift on/off process using ASC	R13	Container cannot enter container yard
		R14	The system is error
		R7	The sensors are error
		R15	Crane is collapsed
		R16	Wire sling snapped
		R58	Power outage
		R59	Container is fall of ASC
C1	Request to take container, ship berth	R17	Misinformation
		R18	Wrong schedule
C2	Container movement from container yard to WSTA	R11	Container cannot enter container yard

Table 4. 4 Potential risk identified from Delphi Questionnaire round 1 questionnaire (con't)

Activity Code	Activity Description	Potential Risk Code	Potential Risk
C3	Container movement from WSTA to dock	R19	Truck hits another truck
D1	Truck enter ASC block	R20	Injury to death
		R21	Vehicle is damaged
		R22	Property is damaged
		R19	Truck hits another truck
		R23	Truck hits concrete barrier
		R24	Air pollution
D2	Twistlock chasis opening by truck driver	R25	Trailer lifted
		R26	Twistlock is not working
		R27	Broken lock
D3	Booth confirmation by driver swap ID	R14	The system is error
		R22	Property is damaged
		R28	ID Card are unidentified
D4	Communication between driver and ASC operator	R29	Truck hits booth
		R21	Vehicle is damaged
		R30	Network malfunction
		R31	Miscommunication between driver and operator
D5	Lift on/off process using ASC	R11	Container cannot enter container yard
		R14	The system is error
		R32	The sensors are error
		R33	Crane is collapsed
		R34	Wire sling snapped
		R58	Power outage
		R59	Container is fall of ASC
D6	Stack container in container yard	R35	Container stack is collapsed
		R36	Incorrect number of stacked container
		R37	Container stack is tilted
		R38	Container stuck
		R39	ASC spreader stuck to the container
		R40	Container's content is spilled
		R41	ASC from water side hit ASC from land side
		R42	Spreader ASC hit stacked container
D7	Stack container in place other than container yard	R43	Wrong mapping

Table 4. 5 Potential risk identified from Delphi Questionnaire round 1 questionnaire (con't)

Activity Code	Activity Description	Potential Risk Code	Potential Risk
D8	Container location confirmation by ASC operator	R44	Misinformation on the container location
		R45	Wrong input for place
E1	Refill Oil	R20	Injury
		R46	Land contamination
		R47	Mechanics poisoned
		R48	Mechanic got electric shocked
		R49	Air tube explode
		R50	Mechanic slipped
		R51	Mechanic touched oil
E2	Replace hose line	R52	Mechanic fall down
		R20	Injury to death
		R46	Land contamination
		R47	Mechanics poisoned
		R50	Mechanic slipped
		R53	Mechanic is crushed
E3	Replace electric motor	R52	Mechanic fall down
		R20	Injury to death
		R46	Land contamination
		R47	Mechanics is poisoned
		R50	Mechanic slipped
		R53	Mechanic is crushed
		R54	Mechanic is wedged
E4	Replace electrical installation	R52	Mechanic fall down
		R20	Injury to death
		R46	Land contamination
		R47	Mechanics is poisoned
		R50	Mechanic slipped
		R53	Mechanic is crushed
		R54	Mechanic is wedged
		R22	Property is damaged
		R55	Hit by vehicle
		R56	Exposed to dangerous material
E5	Automatic Stacking Crane inspection	R52	Mechanic fall down
		R57	Mechanic got electric shocked
		R50	Mechanic slipped
		R54	Mechanic is wedged
		R53	Mechanic is crushed

Source: Author's document

All of the 59 potential risks later will be listed in Delphi questionnaire round 2 to be scored .

4.5.2 Delphi Questionnaire Round 2

In the Delphi Questionnaire round 2, the summary of Delphi Questionnaire round 1 and identified potential risks are presented to respondents. Then, the respondents are asked to score the potential risks to know its validity. Round 2 is conducted on 21 – 22 May 2018.

To score identified potential risks, Likert scale method is being used. If the respondents are very disagree with statement, it will be scored as 1. Score 2 for disagree with statement, 3 for doubt the statement, 4 for agree with the statement, and 5 for very agree with the statement. When finished, the questionnaire will be prorcessed using statisctical measurement such as mean, median, and standard deviation.

The calculation for each measurement will be shown, with the example for potential risk (R1), unmatch order, as follows.

$$\text{Mean} = \frac{3+5+3+5+5}{5}$$

$$= 4{,}2$$

$$\text{Median} = \text{Third datum}$$

$$= 5$$

$$\text{Standard deviation} = \sqrt{\frac{(3-4{,}2)^2+(5-4{,}2)^2+(3-4{,}2)^2+(5-4{,}2)^2+(5-4{,}2)^2}{5-1}}$$

$$= 1{,}10$$

The recapitulation for the calculation will be shown below.

Table 4. 6 Recapitulation of Delphi Questionnaire Round 2 calculation

Activity Code	Potential Risk Code	Potential Risk	Respondents					Mean	Median	Std Deviation
			1	2	3	4	5			
A1	R1	Unmatch order	3	5	3	5	5	4,2	5	1,10
	R2	Unmatch goods	4	3	4	5	4	4	4	0,71
	R3	Container is not suitable to the standard	4	5	5	5	4	4,6	5	0,55

Table 4. 7 Recapitulation of Delphi Questionnaire Round 2 calculation (con't)

Activity Code	Potential Risk Code	Potential Risk	Respondents					Mean	Median	Std Deviation
			1	2	3	4	5			
A2	R4	Trucks tardiness	5	5	4	5	4	4,6	5	0,55
	R5	System filter is not working	5	5	5	5	5	5	5	0,00
	R6	System filter is not matched with the condition (container size, container types, destination, container weight)	5	5	5	4	4	4,6	5	0,55
	R7	The scheduling system is error	5	4	5	5	4	4,6	5	0,55
A3	R8	Wrong input for schedule	4	4	5	4	4	4,2	4	0,45
B1	R9	Damaged tools and equipment	5	4	4	5	4	4,4	4	0,55
	R10	Careless handling by the employee	4	5	4	4	5	4,4	4	0,55
B2	R11	Container cannot enter container yard	4	4	5	4	5	4,4	4	0,55
	R12	Container is dropped in the wrong block	5	4	5	5	4	4,6	5	0,55
B3	R13	Container cannot enter container yard	4	5	4	5	5	4,6	5	0,55
	R14	The system is error	5	4	5	4	4	4,4	4	0,55
	R7	The sensors are error	5	4	4	5	5	4,6	5	0,55
	R15	Crane is collapsed	4	4	4	4	4	4	4	0,00
	R16	Wire sling snapped	4	5	4	5	5	4,6	5	0,55
	R58	Power outage	5	5	5	5	5	5	5	0,00
	R59	Container is fall of ASC	5	5	5	5	5	5	5	0,00
C1	R17	Misinformation	4	4	5	4	5	4,4	4	0,55
	R18	Wrong schedule	3	5	4	4	3	3,8	4	0,84
C2	R11	Container cannot enter container yard	4	5	5	4	5	4,6	5	0,55
C3	R19	Truck hits another truck	4	5	4	4	4	4,2	4	0,45
D1	R20	Injury to death	5	4	4	5	4	4,4	4	0,55
	R21	Vehicle is damaged	5	4	4	4	4	4,2	4	0,45
	R22	Property is damaged	5	4	4	4	5	4,4	4	0,55
	R19	Truck hits another truck	5	5	5	5	4	4,8	5	0,45
	R23	Truck hits concrete barrier	5	4	5	4	4	4,4	4	0,55
	R24	Air pollution	4	4	4	5	5	4,4	4	0,55

Table 4. 8 Recapitulation of Delphi Questionnaire Round 2 calculation (con't)

Activity Code	Potential Risk Code	Potential Risk	Respondents					Mean	Median	Std Deviation
			1	2	3	4	5			
D2	R25	Trailer lifted	4	5	4	4	4	4,2	4	0,45
	R26	Twistlock is not working	5	5	4	4	5	4,6	5	0,55
	R27	Broken lock	3	4	3	4	4	3,6	4	0,55
D3	R14	The system is error	4	5	5	5	5	4,8	5	0,45
	R22	Property is damaged	4	5	5	4	4	4,4	4	0,55
	R28	ID Card are unidentified	4	5	5	5	4	4,6	5	0,55
D4	R29	Truck hits booth	5	5	4	5	4	4,6	5	0,55
	R21	Vehicle is damaged	5	5	4	4	5	4,6	5	0,55
	R30	Network malfunction	5	5	5	5	4	4,8	5	0,45
	R31	Miscommunication between driver and operator	4	5	5	4	5	4,6	5	0,55
D5	R11	Container cannot enter container yard	5	5	4	5	4	4,6	5	0,55
	R14	The system is error	5	5	5	5	4	4,8	5	0,45
	R32	The sensors are error	5	5	4	4	4	4,4	4	0,55
	R33	Crane is collapsed	5	5	5	4	4	4,6	5	0,55
	R34	Wire sling snapped	4	4	5	5	5	4,6	5	0,55
	R58	Power outage	5	5	5	5	5	5	5	0,00
	R59	Container is fall of ASC	5	5	5	5	5	5	5	0,00
D6	R35	Container stack is collapsed	5	4	5	5	4	4,6	5	0,55
	R36	Incorrect number of stacked container	5	4	4	4	5	4,4	4	0,55
	R37	Container stack is tilted	5	5	4	5	4	4,6	5	0,55
	R38	Container stuck	5	4	4	4	5	4,4	4	0,55
	R39	ASC spreader stuck to the container	5	4	5	5	5	4,8	5	0,45
	R40	Container's content is spilled	5	4	4	4	4	4,2	4	0,45
	R41	ASC from water side hit ASC from land side	5	5	5	5	5	5	5	0,00
	R42	Spreader ASC hit stacked container	5	5	5	5	5	5	5	0,00
D7	R43	Wrong mapping	4	5	4	4	4	4,2	4	0,45

Table 4. 9 Recapitulation of Delphi Questionnaire Round 2 calculation (con't)

Activity Code	Potential Risk Code	Potential Risk	Respondents					Mean	Median	Std Deviation
			1	2	3	4	5			
D8	R44	Misinformation on the container location	4	5	4	4	5	4,4	4	0,55
	R45	Wrong input for place	4	5	4	4	4	4,2	4	0,45
E1	R20	Injury	5	5	4	4	4	4,4	4	0,55
	R46	Land contamination	4	4	5	5	5	4,6	5	0,55
	R47	Mechanics poisoned	4	4	4	4	4	4	4	0,00
	R48	Mechanic got electric shocked	5	5	4	5	4	4,6	5	0,55
	R49	Air tube explode	4	5	5	5	5	4,8	5	0,45
	R50	Mechanic slipped	5	4	5	5	5	4,8	5	0,45
	R51	Mechanic touched oil	5	4	5	4	4	4,4	4	0,55
E2	R52	Mechanic fall down	5	4	4	4	5	4,4	4	0,55
	R20	Injury to death	5	5	5	5	4	4,8	5	0,45
	R46	Land contamination	4	5	5	4	5	4,6	5	0,55
	R47	Mechanics poisoned	4	5	4	4	4	4,2	4	0,45
	R50	Mechanic slipped	5	4	4	4	4	4,2	4	0,45
	R53	Mechanic is crushed	5	5	5	5	5	5	5	0,00
E3	R52	Mechanic fall down	5	5	5	5	5	5	5	0,00
	R20	Injury to death	5	4	4	5	4	4,4	4	0,55
	R46	Land contamination	4	4	4	4	4	4	4	0,00
	R47	Mechanics is poisoned	4	4	4	5	5	4,4	4	0,55
	R50	Mechanic slipped	5	5	5	4	4	4,6	5	0,55
	R53	Mechanic is crushed	5	5	4	4	5	4,6	5	0,55
	R54	Mechanic is wedged	5	4	4	4	4	4,2	4	0,45
E4	R52	Mechanic fall down	5	5	4	5	5	4,8	5	0,45
	R20	Injury to death	5	4	5	4	5	4,6	5	0,55
	R46	Land contamination	4	5	4	5	5	4,6	5	0,55
	R47	Mechanics is poisoned	4	4	5	5	4	4,4	4	0,55
	R50	Mechanic slipped	5	5	4	5	4	4,6	5	0,55
	R53	Mechanic is crushed	5	4	5	4	4	4,4	4	0,55
	R54	Mechanic is wedged	5	4	5	4	5	4,6	5	0,55
	R22	Property is damaged	5	4	5	5	4	4,6	5	0,55
	R55	Hit by vehicle	5	5	5	4	5	4,8	5	0,45
	R56	Exposed to dangerous material	4	5	4	4	5	4,4	4	0,55

Table 4. 10 Recapitulation of Delphi Questionnaire Round 2 calculation (con't)

Activity Code	Potential Risk Code	Potential Risk	Respondents					Mean	Median	Std Deviation
			1	2	3	4	5			
E5	R52	Mechanic fall down	5	5	5	4	4	4,6	5	0,55
	R57	Mechanic got electric shocked	5	5	5	5	5	5	5	0,00
	R50	Mechanic slipped	5	5	4	4	5	4,6	5	0,55
	R54	Mechanic is wedged	5	4	4	5	5	4,6	5	0,55
	R53	Mechanic is crushed	5	4	5	5	5	4,8	5	0,45

Source : Author's document

Below is the recapitulation of statistical calculation by graph.

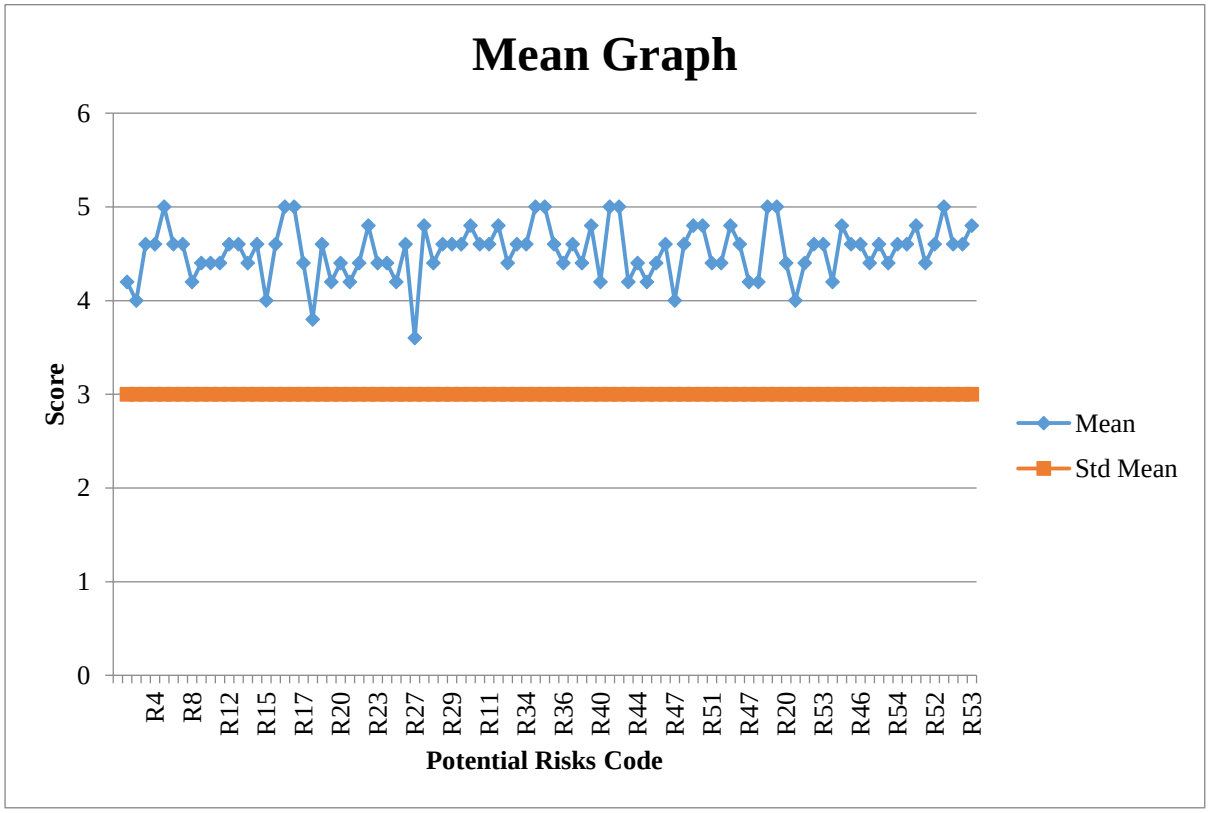


Figure 4. 14 Mean score result of Delphi Questionnaire round 2 graph
Source: Author's document

Based on Figure 4.12, in average respondents agree with the identified risk summaried from Delphi Questionnaire Round 1. All of the score for identified risk average is above 3. The lowest average is 3,6 for R27, broken lock for container in twistlock chasis opening by truck driver process. Meanwhile, the highest average score is 5. This means for several statement, all respondents very agree it should be considered as potential risks. The

potential risk with average score 5 are system filter is not working for scheduling process (R5), ASC water side hit ASC land side for stack container in container yard process (R41), spreader ASC hit stacked container for stack container in container yard process (R42), mechanic is crushed for replace hose line (R53), mechanic fall down for replace electric motor (R52), mechanic got electric shocked for automatic stacking crane inspection (R57), power outage (R58), and container is fall off of ASC (R59).

After the average scores for potential risk is obtained, the score median is calculated next. Since there are five respondents, the median score is the third datum after the data is sorted from lowest score to highest. Figure 4.13 is the processing result of score median Delphi Questionnaire round 2.

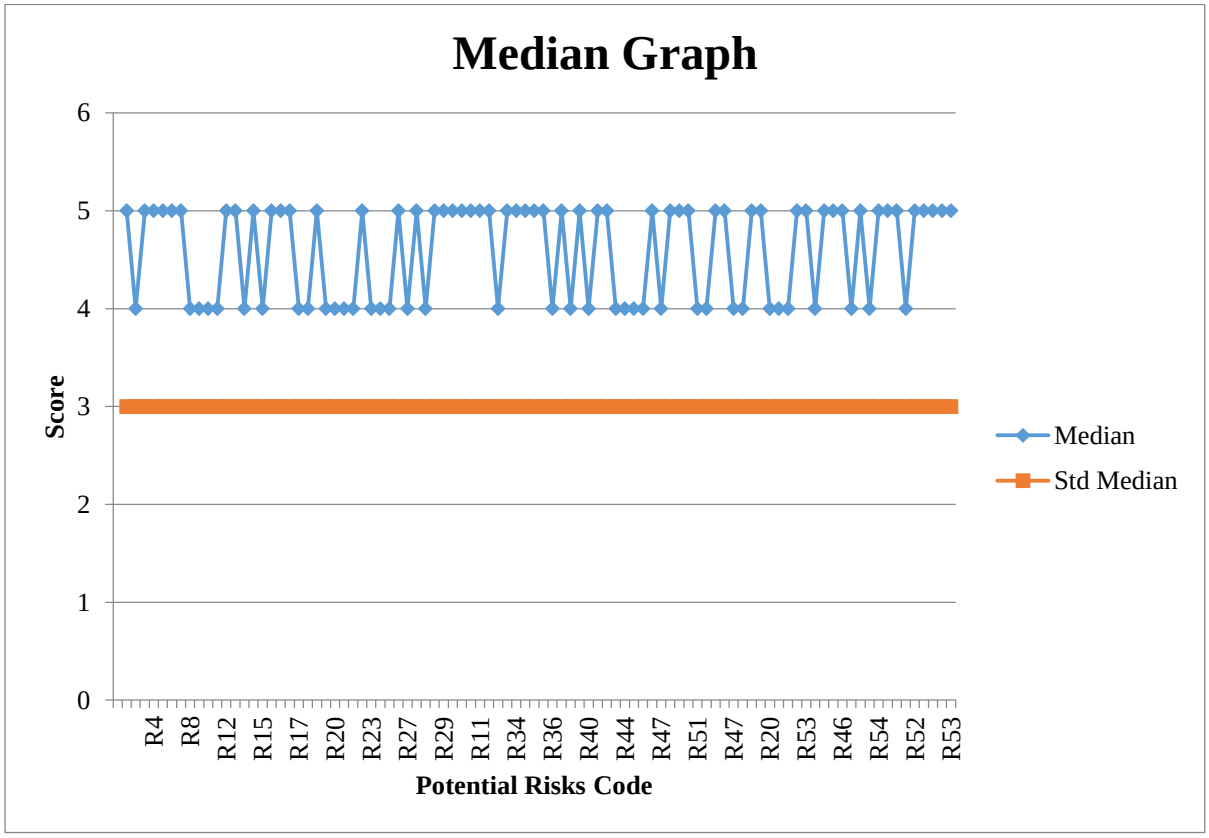


Figure 4. 15 Median score result of Delphi Questionnaire round 2 graph
Source: Author's document

Score 3 is being used as the justification score for the median. It can be seen from Figure 4.13, all of the median scores is either 4 or 5.

The last statistical calculation is standard deviation. A low standard deviation indicates that the data points tend to be close to the mean, which means the data is more

reliable, while a high standard deviation indicated that the data points are spread out over a wider range of score. The standard deviation from Delphi Questionnaire round 2 result can be seen in Figure 4.14.

From the calculation, the standard devation from Delphi Questionnaire round 2 can be considered to be pretty low. Several identified risk even have 0 standard deviation such as system filter is not working for scheduling process (R6), crane is collapsed for lift on/off process using ASC (R15), ASC water side hit ASC land side for stack container in container yard process (R41), spreader ASC hit stacked container for stack container in container yard process (R42), mechanics poisoned for refill oil (R47), mechanic is crushed for replace hose line (R53), mechanic fall down for replace electric motor (R57), power outage (R58), and container is fall off of ASC (R59). The others have standard deviation of 0,45 or 0,54. There are two identified risk with high standard deviation, with wrong schedule for request to take container and ship berth (R20) score is 0,84 and unmatch order for customer order verification (R1) score is 1,10.

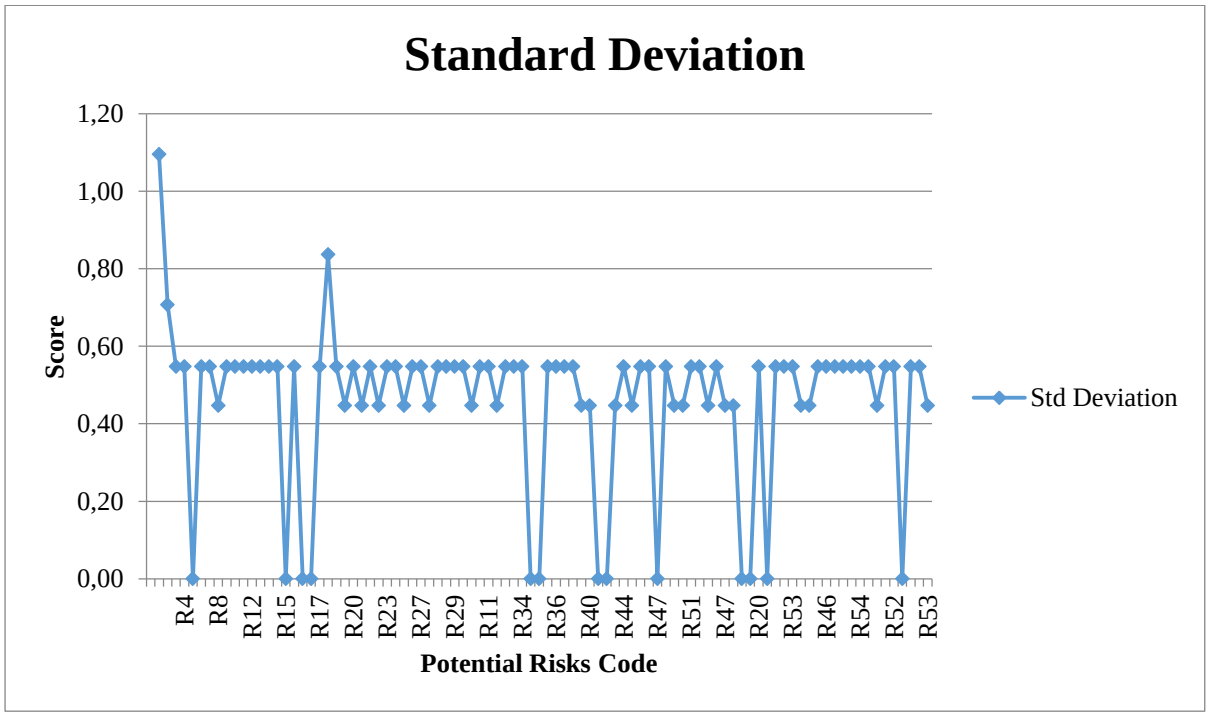


Figure 4. 16 Standard deviation of Delphi Questionnaire round 2 graph
Source: Author's document

Even though from the statistical calculation all of the identified risk can be considered as valid, the author did some discussion with Terminal Teluk Lamong. They think that potential risk R1 should be crossed out since the standard deviation is high, R2 should be

crossed out since it is not the responsibility of Terminal Teluk Lamong to check the content on a container, and potential risk R31 should also be crossed out due to the fact that the mean of the data is low and the responsibility for twist-lock chassis is not fallen on the Terminal Teluk Lamong responsibility, but rather to the container owners.

It is concluded that the consensus is already reached at Delphi Questionnaire round 2. Thus, all of the identified risk other than R1, R2, and R27 using Failure Mode, Effect, and Criticality Analysis (FMECA) to clasify the risk cause, potential effect, and current control. So, the risk prioritization can be done. Then, the relationship among each risk will be found using Decision Making Trial and Evaluation Laboratory (DEMATEL) method. Table 4.5 shows fixed potential risks for the next sub chapter.

Table 4. 11 Fixed identified risk result of Delphi Questionnaire

Activity Code	Activity Description	Potential Risk Code	Potential Risk
A1	Customer Order Verification	R3	Container is not suitable to the standard
		R4	Trucks tardiness
A2	Scheduling process	R5	Trucks tardiness
		R6	System filter is not working
		R7	System filter is not matched with the condition (container size, container types, destination, container weight)
		R8	The scheduling system is error
A3	Scheduling input	R9	Wrong input for schedule
B1	Ship Unloading	R10	Damaged tools and equipment
		R11	Careless handling by the employee
B2	Container movement from dock to WSTA	R12	Container cannot enter container yard
		R13	Container is dropped in the wrong block
B3	Lift on/off process using ASC	R14	Container cannot enter container yard
		R15	The system is error
		R16	The sensors are error
		R17	Crane is collapsed
		R18	Wire sling snapped

Table 4. 12 Fixed identified risk result of Delphi Questionnaire (con't)

Activity Code	Activity Description	Potential Risk Code	Potential Risk
C1	Request to take container, ship berth	R19	Misinformation
		R20	Wrong schedule
C2	Container movement from container yard to WSTA	R21	Container cannot enter container yard
C3	Container movement from WSTA to dock	R22	Truck hits another truck
D1	Truck enter ASC block	R23	Injury to death
		R24	Vehicle is damaged
		R25	Property is damaged
		R26	Truck hits another truck
		R27	Truck hits concrete barrier
		R28	Air pollution
D2	Twistlock chasis opening by truck driver	R29	Trailer lifted
		R30	Twistlock is not working
D3	Booth confirmation by driver swap ID	R32	The system is error
		R33	Broken property
		R34	ID Card are unidentified
D4	Communication between driver and ASC operator	R35	Truck hits booth
		R36	Vehicle is damaged
		R37	Network malfunction
		R38	Miscommunication between driver and operator
D5	Lift on/off process using ASC	R39	Container cannot enter container yard
		R40	The system is error
		R41	The sensors are error
		R42	Crane is collapsed
		R43	Wire sling snapped
D6	Stack container in container yard	R44	Container stack is collapsed
		R45	Incorrect number of stacked container
		R46	Container stack is tilted
		R47	Container stuck
		R48	ASC spreader stuck to the container
		R49	Container's content is spilled
		R50	ASC from water side hit ASC from land side
		R51	Spreader ASC hit stacked container
D7	Stack container in place other than container yard	R52	Wrong mapping

Table 4. 13 Fixed identified risk result of Delphi Questionnaire (con't)

Activity Code	Activity Description	Potential Risk Code	Potential Risk
D8	Container location confirmation by ASC operator	R53	Misinformation on the container location
		R54	Wrong input for place
E1	Refill Oil	R55	Injury
		R56	Land contamination
		R57	Mechanics poisoned
		R58	Mechanic got electric shocked
		R59	Air tube explode
		R60	Mechanic slipped
		R61	Mechanic touched oil
E2	Replace hose line	R62	Mechanic fall down
		R63	Injury to death
		R64	Land contamination
		R65	Mechanics poisoned
		R66	Mechanic slipped
		R67	Mechanic is crushed
E3	Replace electric motor	R68	Mechanic fall down
		R69	Injury to death
		R70	Land contamination
		R71	Mechanics is poisoned
		R72	Mechanic slipped
		R73	Mechanic is crushed
		R74	Mechanic is wedged
E4	Replace electrical installation	R75	Mechanic fall down
		R76	Injury to death
		R77	Land contamination
		R78	Mechanics is poisoned
		R79	Mechanic slipped
		R80	Mechanic is crushed
		R81	Mechanic is wedged
		R82	Equipment is damaged
		R83	Hit by vehicle
		R84	Exposed to dangerous material
E5	Automatic Stacking Crane inspection	R85	Mechanic fall down
		R86	Mechanic got electric shocked
		R87	Mechanic slipped
		R88	Mechanic is wedged
		R89	Mechanic is crushed

Source: Author's document

4.6 Risk Analysis using FMECA Method

Risk analysis using FMECA method begins with potential effect, risk cause, and current control identification to know the severity, occurrence, and detection score in every potential risk to know the prioritized potential risk based on Risk Priority Number (RPN).

4.6.1 Potential Effect, Risk Cause, and Current Control Identification

The identification process of potential effect, risk cause, and current control is conducted in order to know the level of severity, probability of an accident occured, and existing control level. The process of identification is done by observation, interview, and discussion to and with Terminal Teluk Lamong.

Table 4. 14 Potential Effect, Risk Cause, and Current Control of Automatic Stacking Crane's Potential Risk

Potential Risk Code	Potential Risk	Potential Effect	Risk Cause	Currect Control
R3	Container is not suitable to the standard	Container cannot enter the port	• Wrong input • Careless checking • Miscommunication between agent and customer	Scheduling allowance
R4	Trucks tardiness	Container has to stay longer in container yard	• Undisciplined driver • Traffic • High volume of truck	Scheduling allowance
R5	System filter is not working	Wrong pick up	System error	Alghorithm and system maintenance
R6	System filter is not matched with the condition (container size, container types, destination, container weight)	• Wrong pick up • Container cannot enter the port • Container stuck in the container yard • Container has to stay longer in container yard	• Wrong input • System error	Alghorithm and system maintenance
R7	The scheduling system is error	Cannot schedule order	• Wrong algorithm • Bug	Alghorithm and system maintenance
R8	Wrong input for schedule	No place available in container yard	• Careless employee • Wrong information • Miscommunication between agent and customer	Double check for schedule input

Table 4. 15 Potential Effect, Risk Cause, and Current Control of Automatic Stacking Crane's Potential Risk (con't)

Potential Risk Code	Potential Risk	Potential Effect	Risk Cause	Currect Control
R9	Damaged tools and equipment	Tools and equipment cannot be used	• Employee in a rush • Employee do not understand how to use equipment properly	Administrative prevention
R10	Careless handling by the employee	Container is damaged	• Employee in a rush • Employee do not understand how to use equipment properly	Administrative prevention
R11	Container cannot enter container yard	Stack outside of CY	Container is not suitable to the standard	Administrative prevention
R12	Container is dropped in the wrong block	Container is damaged	Misinformation	Double check information
R14	The system is error	• Container cannot be lifted on/off • Wrong stacking	• Wrong algorithm • Bug	Administrative prevention
R15	Crane is collapsed	• Container is damaged • Injured employee	Spare part of crane is damaged	Maintenance
R16	Wire sling snapped	• Container is damaged • Injured employee	Wire sling is strained	Maintenance
R17	Misinformation	• Wrong container placement	Employee is careless	Double check information
R18	Wrong schedule	Unavailable space	Wrong input	Double check information

Table 4. 16 Potential Effect, Risk Cause, and Current Control of Automatic Stacking Crane's Potential Risk (con't)

Potential Risk Code	Potential Risk	Potential Effect	Risk Cause	Currect Control
R19	Truck hits another truck	• Accident • Injured employee • Injured driver	• Driver in rush • Driver and operators are careless • Driver take the truck against the lane • Slippery road	• Install road markings • Install road signs • Paint areas line
R20	Injury to death	• Damaged reputation • Business process is stopped • Financial drawback	• Driver in rush • Driver and operators are careless	All operators and driver in the container yard must use PPE in the process of refilling oil
R21	Vehicle is damaged	Loading unloading process is stopped	Trailer broke down	Trailer maintenance
R22	Property is damaged	Loading unloading process is stopped	Limited trailer course	• Install road markings • Install road signs
R23	Truck hits concrete barrier	• Accident • Injured employee • Injured driver	• Driver in rush • Driver and operators are careless • Slippery road	• Install road markings • Install road signs • Paint areas line
R24	Air pollution	Environmental damage	Long idle time	• Arrange working schedule • Set OH Procedures • Set MCUPre Employment
R25	Trailer lifted	Trailer is damaged	Failed to open the twitslock chasis on all four set	Communication between driver and ASC operator

Table 4. 17 Potential Effect, Risk Cause, and Current Control of Automatic Stacking Crane's Potential Risk (con't)

Potential Risk Code	Potential Risk	Potential Effect	Risk Cause	Currect Control
R26	Twistlock is not working	Loading unloading process is pending	Twistlock is not changed regularly	Maintenance
R28	ID Card are unidentified	Loading unloading process is stopped	Loading unloading process is stopped ID Card is damaged Unclear photos	Administrative prevention
R29	Truck hits booth	• Accident • Injured employee • Injured driver	• Driver in rush • Driver and operators are careless • Slippery road	• Install road markings • Install road signs • Paint areas line
R30	Network malfunction	• System down • Loading unloading process is stopped	• Wrong algorithm • Bug	Alghorithm and system maintenance
R31	Miscommunication between driver and operator	• Loading unloading process is stopped • Container cannot be lifted on/off	• Driver is in a rush • Unclear handy talk	Double check
R32	The sensors are error	• Container cannot be lifted on/off • Wrong stacking • Container is damaged	• Rare maintenance • Circuit is damaged	Sensor inspection
R35	Container stack is collapsed	• Container is damaged • Injured employee	• Container is hit by spreader ASC • Container stack is tilted • Incorrect number of stacked container	Operator supervision

Table 4. 18 Potential Effect, Risk Cause, and Current Control of Automatic Stacking Crane's Potential Risk (con't)

Potential Risk Code	Potential Risk	Potential Effect	Risk Cause	Currect Control
R36	Incorrect number of stacked container	• Container stack is collapsed • Container is damaged	• Bug • Wrong input • Operator sees wrong stack	Operator supervision
R37	Container stack is tilted	• Container stack is collapsed • Container is damaged	• Operator wrong placement	Operator supervision
R38	Container stuck	• Container stack is collapsed • Container is damaged	• Operator wrong placement	Operator supervision
R39	ASC spreader stuck to the container	Container is damaged	• Twistlock is damaged	Operator supervision
R40	Container's content is spilled	• Container is damaged • Goods in the container is damaged	• Container is collapsed	Operator supervision
R41	ASC from water side hit ASC from land side	• ASC is damaged • Loading unloading proccess is stopped	• Bug • Wrong input • Operator in manual mode • Lack of communication	Operator supervision
R42	Spreader ASC hit stacked container	• ASC is damaged • Loading unloading proccess is stopped • Container is damaged	• Bug • Wrong input • Operator sees wrong stack	Operator supervision
R43	Wrong mapping	Wrong location of container	• Wrong input • Miscommunication	Operator supervision

Table 4. 19 Potential Effect, Risk Cause, and Current Control of Automatic Stacking Crane's Potential Risk (con't)

Potential Risk Code	Potential Risk	Potential Effect	Risk Cause	Currect Control
R44	Misinformation on the container location	Wrong location of container	Wrong input	• Double check • Administrative prevention • Operator supervision
R45	Wrong input for place	Wrong location of container	• Wrong input • Miscommunication	Operator supervision
R46	Land contamination	Environmental damage	• Absence of PPE • Work in heights • Position of mechanics is not right • Lack of light	Primary oil shelter
R47	Mechanics poisoned	• Damaged reputation • Business process is stopped • Financial drawbacks	• Oil spilled • Oil fumes are inhaled by mechanics	Mechanics must use PPE in the process of refilling oil
R48	Mechanic got electric shocked	• Damaged reputation • Business process is stopped • Financial drawbacks	• Cable peeled off • Absence of gloves	Mechanics must use PPE in the process of refilling oil
R49	Air tube explode	• Damaged reputation • Business process is stopped • Financial drawbacks	• High presssured air • Compressor hose peeled off • Compressor indicator do not work • Compressor tube in rut	• Install safety cone • Install police line

Table 4. 20 Potential Effect, Risk Cause, and Current Control of Automatic Stacking Crane's Potential Risk (con't)

Potential Risk Code	Potential Risk	Potential Effect	Risk Cause	Currect Control
R50	Mechanic slipped	• Damaged reputation • Business process is stopped • Financial drawbacks	• Lack of cleaning • Oil spilled • Unsuitable shoes	Mechanics must use PPE in the process of refilling oil
R51	Mechanic touched oil	• Damaged reputation • Business process is stopped • Financial drawbacks	• Hot Oil • Absence of PPE	Mechanics must use PPE in the process of refilling oil
R52	Mechanic fall down	• Damaged reputation • Business process is stopped • Financial drawbacks	• Absence of PPE • Work in heights • Position of mechanics is not right • Lack of light	Mechanics must use PPE in the process of refilling oil
R53	Mechanic is crushed	• Damaged reputation • Business process is stopped • Financial drawbacks	Equipment falls on the mechanics body/head	Mechanics must use PPE in the process of refilling oil
R54	Mechanic is wedged	• Damaged reputation • Business process is stopped • Financial drawbacks	• Crane is not fit • Sling is not fit	Mechanics must use PPE in the process of refilling oil
R55	Hit by vehicle	• Accident • Injured employee • Injured driver	• Mechanics are not aware by vehicle • Driver pass the forbidden area • Driver unfocused	Mechanics must use PPE in the process of refilling oil

Table 4. 21 Potential Effect, Risk Cause, and Current Control of Automatic Stacking Crane's Potential Risk (con't)

Potential Risk Code	Potential Risk	Potential Effect	Risk Cause	Currect Control
R56	Exposed to dangerous material	• Damaged reputation • Business process is stopped • Financial drawbacks	• Dangerous materials spilled • Oil fumes are inhaled by mechanics • Absence of PPE use	Mechanics must use PPE in the process of refilling oil
R58	Power outage	Loading and unloading process is stopped	External supplier decides to do so	Mechanics must use PPE in the process of refilling oil
R59	Container is fall of ASC	Container is damaged	Wire sling is strained	Mechanics must use PPE in the process of refilling oil

Source: Author's document

4.6.2 Severity, Occurence, and Detection Scoring

To determine the scores of severity, occurrence, and detection, questionnaire is given to three persons expected to be expected, which are Head of Operation, Head of Automatic Stacking Crane Operation, and Head of Maintenance. The questionnaire is conducted on 30 May 2018 – 7 June 2018.

The scoring criteria is based on the risk management scoring established by PT Pelindo III as Terminal Teluk Lamong is its subsidiary, using 1 – 5 scale. Below is the result of severity, occurence, and detection scoring by experts.

Table 4. 22 Severity, occurence, and detection scale

Score	Severity Definition	Occurence Definition	Detection Definition
1	Insignificant	Rare	Detected without checking
2	Minor	Unlikely	Detected in periodic inspection
3	Moderate	Possible	Detected in full maintenance
4	Major	Likely	Detected if it is hard look
5	Catasthropic	Almost Certain	Undetected even though it is hard look

Source: Company's document

Table 4. 23 Severity, occurence, and detection scoring result

Potential Risk Code	Potential Risk	Average Severity Score	Average Occurence Score	Average Detection Score
R3	Container is not suitable to the standard	2	2	2
R4	Trucks tardiness	2	2	2
R5	System filter is not working	2	2	2
R6	System filter is not matched with the condition (container size, container types, destination, container weight)	2	2	2
R7	The scheduling system is error	2	2	2
R8	Wrong input for schedule	2	2	2
R9	Damaged tools and equipment	2	2	2
R10	Careless handling by the employee	2	3	2
R11	Container cannot enter container yard	2	3	2
R12	Container is dropped in the wrong block	2	3	2

Table 4. 24 Severity, occurence, and detection scoring result (con't)

Potential Risk Code	Potential Risk	Average Severity Score	Average Occurence Score	Average Detection Score
R14	The system is error	2	2	3
R15	Crane is collapsed	4	2	1
R16	Wire sling snapped	4	2	2
R17	Misinformation	2	2	2
R18	Wrong schedule	2	2	2
R19	Truck hits another truck	4	2	3
R20	Injury to death	4	1	1
R21	Vehicle is damaged	3	2	2
R22	Property is damaged	3	2	2
R23	Truck hits concrete barrier	3	2	2
R24	Air pollution	3	2	3
R25	Trailer lifted	3	2	2
R26	Twistlock is not working	3	3	2
R28	ID Card are unidentified	2	3	1
R29	Truck hits booth	3	2	2
R30	Network malfunction	2	2	2
R31	Miscommunication between driver and operator	3	2	2
R32	The sensors are error	3	2	2
R35	Container stack is collapsed	5	2	2
R36	Incorrect number of stacked container	3	2	2
R37	Container stack is tilted	4	2	2
R38	Container stuck	3	2	2
R39	ASC spreader stuck to the container	4	3	3
R40	Container's content is spilled	4	2	2
R41	ASC from water side hit ASC from land side	5	2	2
R42	Spreader ASC hit stacked container	5	2	2
R43	Wrong mapping	2	2	2
R44	Misinformation on the container location	2	2	2
R45	Wrong input for place	2	2	2
R46	Land contamination	3	2	2
R47	Mechanics poisoned	4	1	1
R48	Mechanic got electric shocked	4	2	1
R49	Air tube explode	5	1	2
R50	Mechanic slipped	4	1	2
R51	Mechanic touched oil	4	1	1
R52	Mechanic fall down	4	1	1

Table 4. 25 Severity, occurence, and detection scoring result (con't)

Potential Risk Code	Potential Risk	Average Severity Score	Average Occurence Score	Average Detection Score
R53	Mechanic is crushed	4	1	1
R54	Mechanic is wedged	4	1	1
R55	Hit by vehicle	4	1	1
R56	Exposed to dangerous material	4	2	2
R58	Power outage	4	3	3
R59	Container is fall of ASC	4	3	2

Source: Author's document

4.6.3 Risk Priority Number (RPN) Score Calculation

To calculate Risk Priority Number, severity, occurrence, and detection score from the questionnaire will be multiplied. From RPN score, the critical risk will be known. Below is the example calculation of Risk Priority Number for Risk 3.

$$\begin{aligned} RPN &= \\ &= 2 \times 2 \times 2 \\ &= 8 \end{aligned}$$

Table 4.8 shows the recapitulation of the RPN calculation.

Table 4. 26 Severity, occurence, and detection result

Potential Risk Code	Potential Risk	RPN
R3	Container is not suitable to the standard	8
R4	Trucks tardiness	8
R5	System filter is not working	8
R6	System filter is not matched with the condition (container size, container types, destination, container weight)	8
R7	The scheduling system is error	8
R8	Wrong input for schedule	8
R9	Damaged tools and equipment	8
R10	Careless handling by the employee	12
R11	Container cannot enter container yard	12
R12	Container is dropped in the wrong block	12
R14	The system is error	12
R15	Crane is collapsed	8

Table 4. 27 Severity, occurence, and detection result (con't)

Potential Risk Code	Potential Risk	RPN
R16	Wire sling snapped	16
R17	Misinformation	8
R18	Wrong schedule	8
R19	Truck hits another truck	24
R20	Injury to death	4
R21	Vehicle is damaged	12
R22	Property is damaged	12
R23	Truck hits concrete barrier	12
R24	Air pollution	18
R25	Trailer lifted	12
R26	Twistlock is not working	18
R28	ID Card are unidentified	6
R29	Truck hits booth	12
R30	Network malfunction	8
R31	Miscommunication between driver and operator	12
R32	The sensors are error	12
R35	Container stack is collapsed	20
R36	Incorrect number of stacked container	12
R37	Container stack is tilted	16
R38	Container stuck	12
R39	ASC spreader stuck to the container	36
R40	Container's content is spilled	16
R41	ASC from water side hit ASC from land side	20
R42	Spreader ASC hit stacked container	20
R43	Wrong mapping	8
R44	Misinformation on the container location	8
R45	Wrong input for place	8
R46	Land contamination	12
R47	Mechanics poisoned	4
R48	Mechanic got electric shocked	8
R49	Air tube explode	10
R50	Mechanic slipped	8
R51	Mechanic touched oil	4
R52	Mechanic fall down	4
R53	Mechanic is crushed	4
R54	Mechanic is wedged	4
R55	Hit by vehicle	4
R56	Exposed to dangerous material	16
R58	Power outage	36
R59	Container is fall of ASC	24

Source: Author's document

4.7 Risk Evaluation

Risk evaluation will be done by determine the ranking of each risks based on the RPN and create risk mapping based on the score of severity and occurence.

4.7.1 Risk Ranking Determination

The rank of risks will be determined based on the calculation in sub chapter 4.6.3 about Risk Priority Number of each risks. The risk ranking determination will be used to see which risks should be handled first. The higher the RPN, the higher the chance for the risk to be identified as highly urgent mitigated. Table 4.9 shows the result of risk ranking determination.

Table 4. 28 Risk priority number of each potential risk

Potential Risk Code	Potential Risk	RPN
R39	ASC spreader stuck to the container	36
R58	Power outage	36
R19	Truck hits another truck	24
R59	Container is fall of ASC	24
R35	Container stack is collapsed	20
R41	ASC from water side hit ASC from land side	20
R42	Spreader ASC hit stacked container	20
R24	Air pollution	18
R26	Twistlock is not working	18
R16	Wire sling snapped	16
R37	Container stack is tilted	16
R40	Container's content is spilled	16
R56	Exposed to dangerous material	16
R10	Careless handling by the employee	12
R11	Container cannot enter container yard	12
R12	Container is dropped in the wrong block	12
R14	The system is error	12
R21	Vehicle is damaged	12
R22	Property is damaged	12
R23	Truck hits concrete barrier	12
R25	Trailer lifted	12
R29	Truck hits booth	12
R31	Miscommunication between driver and operator	12
R32	The sensors are error	12
R36	Incorrect number of stacked container	12
R38	Container stuck	12
R46	Land contamination	12
R49	Air tube explode	10

Table 4. 29 Risk priority number of each potential risk (con't)

Potential Risk Code	Potential Risk	RPN
R3	Container is not suitable to the standard	8
R4	Trucks tardiness	8
R5	System filter is not working	8
R6	System filter is not matched with the condition (container size, container types, destination, container weight)	8
R7	The scheduling system is error	8
R8	Wrong input for schedule	8
R9	Damaged tools and equipment	8
R15	Crane is collapsed	8
R17	Misinformation	8
R18	Wrong schedule	8
R30	Network malfunction	8
R43	Wrong mapping	8
R44	Misinformation on the container location	8
R45	Wrong input for place	8
R48	Mechanic got electric shocked	8
R50	Mechanic slipped	8
R28	ID Card are unidentified	6
R20	Injury to death	4
R47	Mechanics poisoned	4
R51	Mechanic touched oil	4
R52	Mechanic fall down	4
R53	Mechanic is crushed	4
R54	Mechanic is wedged	4
R55	Hit by vehicle	4

Source: Author's document

4.7.2 Risk Mapping

The result of risk scoring which is based on the criteria of severity, occurence, and detection in the sub chapter 4.6.2 will be used as the input for the risk mapping, considering two scoring criterias, which are severity as the x-axis and occurence as the y-axis.

The determination whether the mapping is in the high, medium, low, or very low risk is based on the risk mapping that PT Pelido III established, as Terminal Teluk Lamong is its subsidiary.

In Figure 4.17, it can be seen the area of risk mapping based on the risk level, divided into three: very low area with color green; low area with color yellow; medium area with color orange; and high area with color red. For example, in potential risk R3, with severity score is 4 and occurence score is 5, R3 will be placed in the red area, or high risk area. .

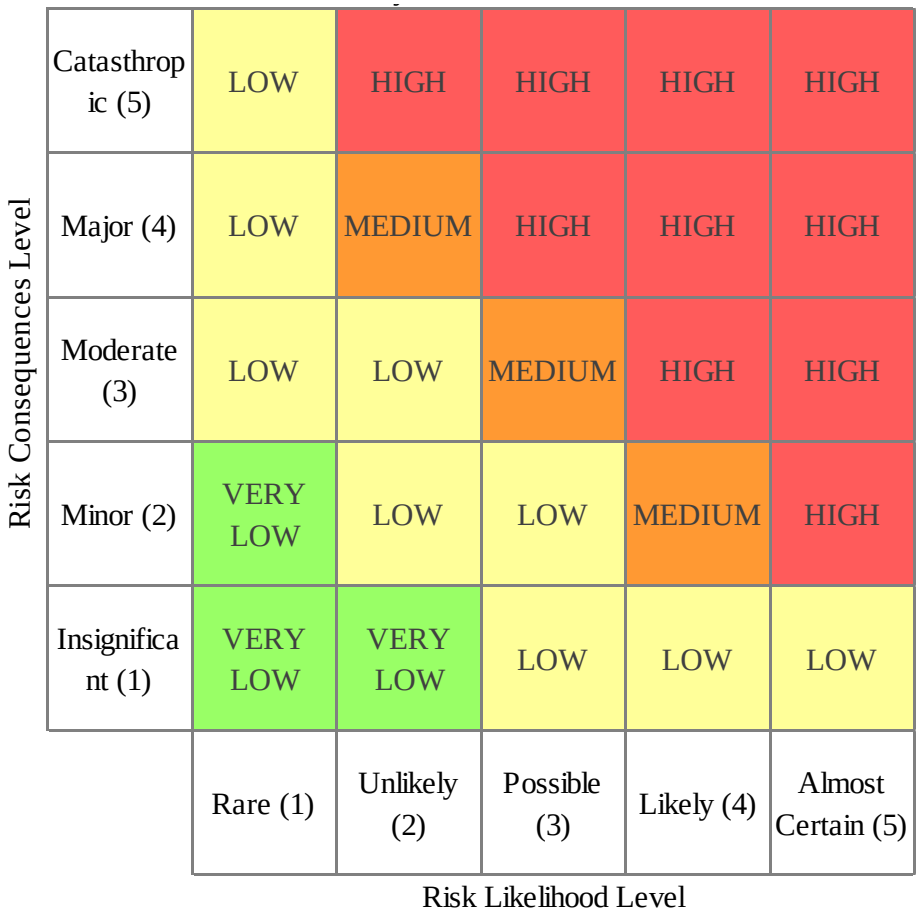


Figure 4. 17 Risk mapping are determination

All of the risks then will be placed in its respectful area just like in the the Figure 4.18.

In this research, risk mapping is done in two iterations. First iterations is determining the risk category based on severity and occurence score. After that, second iteration is conducted by cross checking the risk category to the expert to know the criticality of the risks.

Cross checking process is very important in the risk mapping design because the expert is the people who actually know what is going on in Terminal Teluk Lamong. The expert in this case are QHSSE department as the Risk Agent of Terminal Teluk Lamong. As the result, all of the potential risk related to their employees is changed from low risk into high risk category which are R20, R47, R49, R50, R51, R52, R53, R54, and R55.. Table 4.11 shows the final risk category determination for Automatic Stacking Crane.

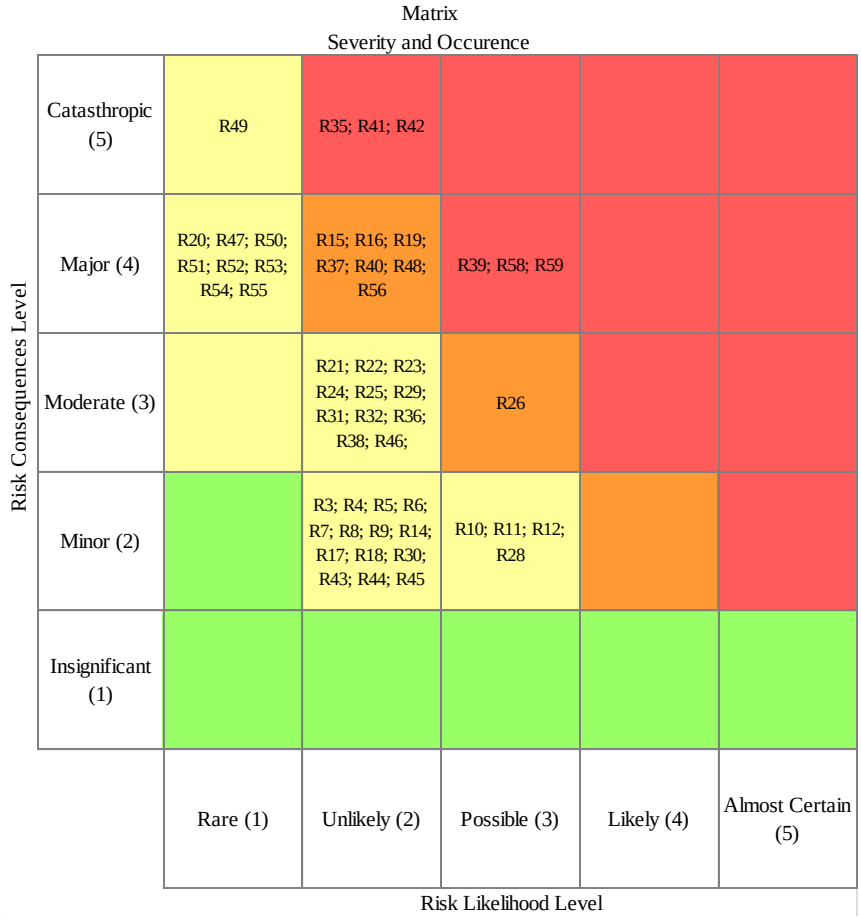


Figure 4. 18 Risk Mapping Result

Table 4. 30 Risk mapping determination result

Potential Risk Code	Potential Risk	RPN	Risk Category
R39	ASC spreader stuck to the container	36	High
R58	Power outage	36	High
R19	Truck hits another truck	24	Medium
R59	Container is fall of ASC	24	High
R35	Container stack is collapsed	20	High
R41	ASC from water side hit ASC from land side	20	High
R42	Spreader ASC hit stacked container	20	High
R24	Air pollution	18	Low
R26	Twistlock is not working	18	Medium
R16	Wire sling snapped	16	Medium
R37	Container stack is tilted	16	Medium
R40	Container's content is spilled	16	Medium
R56	Exposed to dangerous material	16	Medium
R10	Careless handling by the employee	12	Low
R11	Container cannot enter container yard	12	Low
R12	Container is dropped in the wrong block	12	Low

Table 4. 31 Risk mapping determination result (con't)

Potential Risk Code	Potential Risk	RPN	Risk Category
R14	The system is error	12	Low
R21	Vehicle is damaged	12	Low
R22	Property is damaged	12	Low
R23	Truck hits concrete barrier	12	Low
R25	Trailer lifted	12	Low
R29	Truck hits booth	12	Low
R31	Miscommunication between driver and operator	12	Low
R32	The sensors are error	12	Low
R36	Incorrect number of stacked container	12	Low
R38	Container stuck	12	Low
R46	Land contamination	12	High
R49	Air tube explode	10	High
R3	Container is not suitable to the standard	8	Low
R4	Trucks tardiness	8	Low
R5	System filter is not working	8	Low
R6	System filter is not matched with the condition (container size, container types, destination, container weight)	8	Low
R7	The scheduling system is error	8	Low
R8	Wrong input for schedule	8	Low
R9	Damaged tools and equipment	8	Low
R15	Crane is collapsed	8	Medium
R17	Misinformation	8	Low
R18	Wrong schedule	8	Low
R30	Network malfunction	8	Low
R43	Wrong mapping	8	Low
R44	Misinformation on the container location	8	Low
R45	Wrong input for place	8	Low
R48	Mechanic got electric shocked	8	High
R50	Mechanic slipped	8	High
R28	ID Card are unidentified	6	Low
R20	Injury to death	4	High
R47	Mechanics poisoned	4	High
R51	Mechanic touched oil	4	High
R52	Mechanic fall down	4	High
R53	Mechanic is crushed	4	High
R54	Mechanic is wedged	4	High
R55	Hit by vehicle	4	High

4.8 Risk Correlation Identification using DEMATEL Method

In this step, the relationship of each risk will be identified so that the structured model can be build using DEMATEL method.

The data for risk correlation is obtained byDEMATEL questionnaire filled by experts which are Head of Operation, Head of Automatic Stacking Crane Operation, and Head of Maintenance. The questionnaire is conducted on 30 May 2018 – 7 June 2018.

The result of lingkages of each risks in DEMATEL method will show inner dependence relationship in Impach Diagraph Map. The DEMATEL method processes in total has three steps: direct relationship matrix; normalization matrix, and total relationship matrix.

4.8.1 Direct Relationship Matrix

Direct relationship matrix is a matrix of result recapitulation of the questionnaire result on the relationship of each risks. In the direct relationship matrix, Likert scale is used, with the definition score as below.

0 – No effect
1 – Low effect
2 – Medium effect
3 – High effect
4 – Very high effect

In the direct relationship matrix, the sum of rows and columns are calculated to know the score of k using Microsoft Excel software.

		Hit by vehicle	Exposed to dangerous material	Power outage	Container is fall of ASC	Total
		R55	R56	R58	R59	
R3	Container is not suitable to the standard	0	0	0	4	27
R4	Trucks tardiness	1	1	0	0	49
R58	Power outage	0	0	0	0	27
R59	Container is fall of ASC	0	0	0	0	40
	Total	9	9	19	40	0,01428571

Figure 4. 19 k-score Determination
Source : Author's document

4.8.2 Normalization Matrix

After the direct relationship matrix is done calculated, normalization of the direct relationship matrix is made using formula on sub chapter 2.6.2 using Microsoft Excel software. The result of normalization matrix is shown in Figure 4.20.

		Container is not suitable to the standard	Trucks tardiness	System filter is not working	System filter is not matched with the condition (container size, container types, destination, container weight)	The scheduling system is error	Wrong input for schedule
		R3	R4	R5	R6	R7	R8
R3	Container is not suitable to the standard	0	0	0,02857	0,04286	0,02857	0
R4	Trucks tardiness	0,01429	0	0	0,02857	0,02857	0,02857
R58	Power outage	0	0	0,05714	0	0	0
R59	Container is fall of ASC	0,05714	0	0	0	0	0

Figure 4. 20 Normalization Matrix Calculation
Source : Author's document

4.8.3 Total Relationship Matrix

After the normalization matrix is done calculated, the next step is calculating total relationship matrix using formula in sub chapter 2.6.3. To obtain total relationship matrix, identity matrix is made using Microsoft Excel software, then substracted by matrix X to get matrix $(I - X)^{-1}$.

1	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0	0
0	0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0	1	0
0	0	0	0	0	0	0	0	0	1

Figure 4. 21 Identity Matrix (52 × 52)
Source : Author's document

		Container is not suitable to the standard	Trucks tardiness	System filter is not working	System filter is not matched with the condition (container size, container types, destination, container weight)	The scheduling system is error	Wrong input for schedule
		R3	R4	R5	R6	R7	R8
R3	Container is not suitable to the standard	1	0	-0,0286	-0,0429	-0,0286	0
R4	Trucks tardiness	-0,0143	1	0	-0,0286	-0,0286	-0,0286
R58	Power outage	0	0	-0,0571	0	0	0
R59	Container is fall of ASC	-0,0571	0	0	0	0	0

Figure 4. 22 Matrix (I - X)
Source : Author's document

		Container is not suitable to the standard	Trucks tardiness	System filter is not working	System filter is not matched with the condition (container size, container types, destination, container weight)	The scheduling system is error	Wrong input for schedule
		R3	R4	R5	R6	R7	R8
R3	Container is not suitable to the standard	1,01321	0,0054	0,03997	0,05449	0,04249	0,00791
R4	Trucks tardiness	0,02238	1,01228	0,01557	0,04091	0,04293	0,03775
R58	Power outage	0,00336	0,00393	0,06393	0,00924	0,01197	0,00369
R59	Container is fall of ASC	0,06875	0,00189	0,01167	0,01218	0,01516	0,00177

Figure 4. 23 Matrix $(I - X)^{-1}$
Source : Author's document

The last step is multiplicate matrices using Microsoft Excel software as shown below.

		Container is not suitable to the standard	Trucks tardiness	System filter is not working	System filter is not matched with the condition (container size, container types, destination, container weight)	The scheduling system is error	Wrong input for schedule
		R3	R4	R5	R6	R7	R8
R3	Container is not suitable to the standard	0,01321	0,0054	0,03997	0,05449	0,04249	0,00791
R4	Trucks tardiness	0,02238	0,01228	0,01557	0,04091	0,04293	0,03775
R58	Power outage	0,00336	0,00393	0,06393	0,00924	0,01197	0,00369
R59	Container is fall of ASC	0,06875	0,00189	0,01167	0,01218	0,01516	0,00177

Figure 4. 24 Total Relationship Matrix
Source : Author's document

4.8.4 Dispatcher Vector and Receiver Vector

After the total relationship matrix is calculated, the next step is calculating dispatcher vector and receiver vector. Dispatcher and reveiver vectors are used to calculate the prominence (D + R) so that the importance of the risks is known, and to calculate the relation (D – R) to see the causation relationship of the risk for Automatic Stacking Crane.

The calculation of dispatcher vector is conducted by sum up the rows in the total relationship matrix, whilst for receiver vector is gotten by sum up the column in the total relationship matrix. Then, the total evarage from the total relationship matrix is calculated. If the score on total relationship matrix is less than the average, then there is no relationship from a certain risk to another certain risk. It it is more than, there is a relationship. The result of the calculation will be shown below.

		Mechanic is crushed	Mechanic is wedged	Hit by vehicle	Exposed to dangerous material	Power outage	Container is fall of ASC	Total
		R53	R54	R55	R56	R58	R59	
								DISPATCHER
R3	Container is not suitable to the standard	0,00096	0,00096	0,00095	0,00095	0,00644	0,06843	0,63774777
R4	Trucks tardiness	0,01757	0,01757	0,01732	0,01732	0,00432	0,01298	1,00523817
R58	Power outage	0,00162	0,00162	0,0016	0,0016	0,01409	0,00677	0,5796231
R59	Container is fall of ASC	0,0033	0,0033	0,00325	0,00325	0,00845	0,03855	0,89941912
	Receiver	0,20519	0,20519	0,18822	0,18822	0,44909	0,82902	0,00735678

Figure 4. 25 Dispactcher and receiver calculation
Source : Author's document

		Container is not suitable to the standard	Trucks tardiness	System filter is not working	System filter is not matched with the condition (container size, container types, destination, container weight)	The scheduling system is error	Wrong input for schedule
		R3	R4	R5	R6	R7	R8
R3	Container is not suitable to the standard	RELATED	NOT RELATED	RELATED	RELATED	RELATED	RELATED
R4	Trucks tardiness	RELATED	RELATED	RELATED	RELATED	RELATED	RELATED
R58	Power outage	NOT RELATED	NOT RELATED	RELATED	RELATED	RELATED	NOT RELATED

Figure 4. 26 Risk Relationship Matrix
Source: Author's document

After the risk relation matrix is onbatiner, to know which risk has higher impact to another risk, dispatcher and receiver vector is add or substracted by each other. The result of the calculation is named (D + R) and (D – R), as shown below.

Table 4. 32 Result of calcuation (D + R) and (D – R)

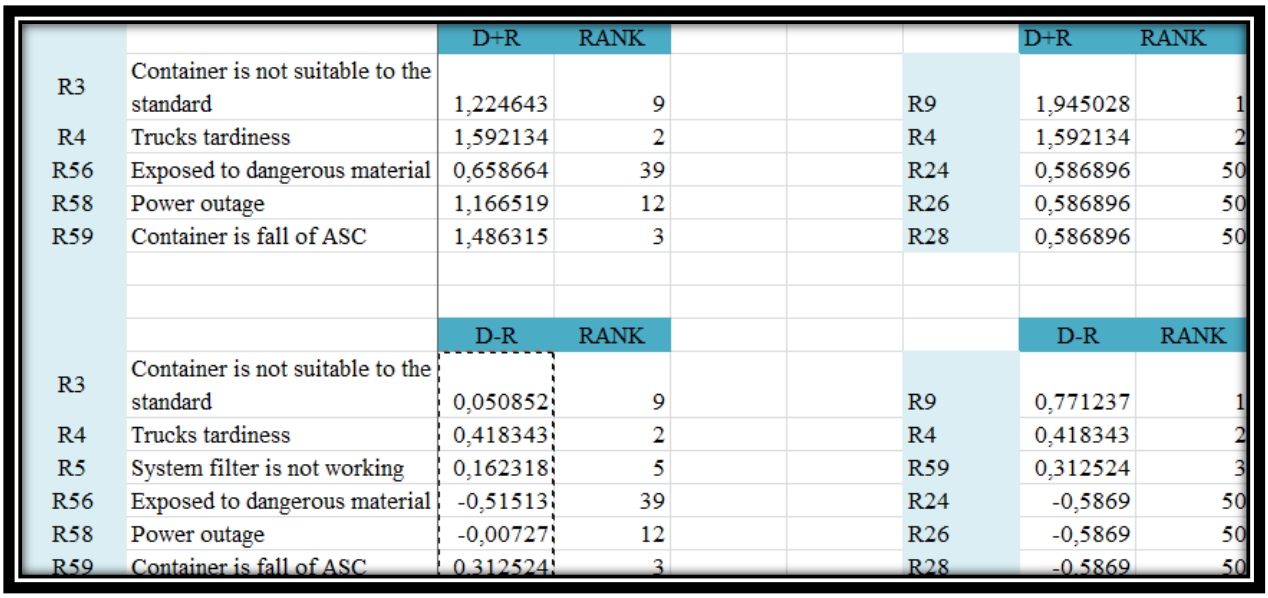
Code Risk	Potential Risk	D + R	D – R
R3	Container is not suitable to the standard	1,2246433	0,0508522
R4	Trucks tardiness	1,5921337	0,4183426
R5	System filter is not working	1,3361093	0,1623183
R6	System filter is not matched with the condition (container size, container types, destination, container weight)	1,1798102	0,0060192
R7	The scheduling system is error	1,2526942	0,0789031
R8	Wrong input for schedule	1,1675731	-0,006218
R9	Damaged tools and equipment	1,9450282	0,7712371
R10	Careless handling by the employee	0,7606753	-0,413116
R11	Container cannot enter container yard	1,4318647	0,2580737
R12	Container is dropped in the wrong block	0,6132522	-0,560539
R14	The system is error	0,7336638	-0,440127
R15	Crane is collapsed	0,812128	-0,361663
R16	Wire sling snapped	1,0821106	-0,09168
R17	Misinformation	1,0121378	-0,161653

Table 4. 33 Result of calcuation (D + R) and (D – R) (con't)

Code Risk	Potential Risk	D + R	D – R
R18	Wrong schedule	1,0121378	-0,161653
R19	Truck hits another truck	0,8775703	-0,296221
R20	Injury to death	1,261488	0,0876969
R21	Vehicle is damaged	0,9267835	-0,247008
R22	Property is damaged	0,9165096	-0,257281
R23	Truck hits concrete barrier	0,8705285	-0,303263
R24	Air pollution	0,5868955	-0,586896
R25	Trailer lifted	0,9149709	-0,25882
R26	Twistlock is not working	0,5868955	-0,586896
R28	ID Card are unidentified	0,5868955	-0,586896
R29	Truck hits booth	0,927446	-0,246345
R30	Network malfunction	1,3007064	0,1269154
R31	Miscommunication between driver and operator	0,8804588	-0,293332
R32	The sensors are error	1,054499	-0,119292
R35	Container stack is collapsed	1,1259348	-0,047856
R36	Incorrect number of stacked container	1,0170706	-0,15672
R37	Container stack is tilted	1,1256089	-0,048182
R38	Container stuck	1,1256089	-0,048182
R39	ASC spreader stuck to the container	1,1256089	-0,048182
R40	Container's content is spilled	1,1256089	-0,048182
R41	ASC from water side hit ASC from land side	0,8952426	-0,278548
R42	Spreader ASC hit stacked container	0,9787048	-0,195086
R43	Wrong mapping	0,914734	-0,259057
R44	Misinformation on the container location	0,9905547	-0,183236
R45	Wrong input for place	0,9938041	-0,179987
R46	Land contamination	1,0188391	-0,154952
R47	Mechanics poisoned	0,644188	-0,529603
R48	Mechanic got electric shocked	0,644188	-0,529603
R49	Air tube explode	0,6324149	-0,541376
R50	Mechanic slipped	0,644188	-0,529603
R51	Mechanic touched oil	0,644188	-0,529603
R52	Mechanic fall down	0,644188	-0,529603
R53	Mechanic is crushed	0,644188	-0,529603
R54	Mechanic is wedged	0,6586638	-0,515127
R55	Hit by vehicle	0,6586638	-0,515127
R56	Exposed to dangerous material	0,6586638	-0,515127
R58	Power outage	1,1665186	-0,007272
R59	Container is fall of ASC	1,4863147	0,3125236

Source: Author's document

The result of (D + R) and (D – R) calculation is then ranked based on the score using Microsoft Excel software as shown below.



		D+R	RANK			D+R	RANK
R3	Container is not suitable to the standard	1,224643	9		R9	1,945028	1
R4	Trucks tardiness	1,592134	2		R4	1,592134	2
R56	Exposed to dangerous material	0,658664	39		R24	0,586896	50
R58	Power outage	1,166519	12		R26	0,586896	50
R59	Container is fall of ASC	1,486315	3		R28	0,586896	50

		D-R	RANK			D-R	RANK
R3	Container is not suitable to the standard	0,050852	9		R9	0,771237	1
R4	Trucks tardiness	0,418343	2		R4	0,418343	2
R5	System filter is not working	0,162318	5		R59	0,312524	3
R56	Exposed to dangerous material	-0,51513	39		R24	-0,5869	50
R58	Power outage	-0,00727	12		R26	-0,5869	50
R59	Container is fall of ASC	0,312524	3		R28	-0,5869	50

Figure 4. 27 Result of (D + R) and (D – R) calculation
Source: Author's document

Table 4. 34 Risk Ranking based on (D + R) and (D – R) calculation

Rank	Code Risk	Potential Risk	D+R	D-R
1	R9	Damaged tools and equipment	1,9450282	0,7712371
2	R4	Trucks tardiness	1,5921337	0,4183426
3	R59	Container is fall of ASC	1,4863147	0,3125236
4	R11	Container cannot enter container yard	1,4318647	0,2580737
5	R5	System filter is not working	1,3361093	0,1623183
6	R30	Network malfunction	1,3007064	0,1269154
7	R20	Injury to death	1,261488	0,0876969
8	R7	The scheduling system is error	1,2526942	0,0789031
9	R3	Container is not suitable to the standard	1,2246433	0,0508522
10	R6	System filter is not matched with the condition (container size, container types, destination, container weight)	1,1798102	0,0060192
11	R8	Wrong input for schedule	1,1675731	-0,006218
12	R58	Power outage	1,1665186	-0,007272
13	R35	Container stack is collapsed	1,1259348	-0,047856
14	R37	Container stack is tilted	1,1256089	-0,048182
15	R38	Container stuck	1,1256089	-0,048182
16	R39	ASC spreader stuck to the container	1,1256089	-0,048182
17	R40	Container's content is spilled	1,1256089	-0,048182
18	R16	Wire sling snapped	1,0821106	-0,09168
19	R32	The sensors are error	1,054499	-0,119292
20	R46	Land contamination	1,0188391	-0,154952
21	R36	Incorrect number of stacked container	1,0170706	-0,15672
22	R17	Misinformation	1,0121378	-0,161653
23	R18	Wrong schedule	1,0121378	-0,161653
24	R45	Wrong input for place	0,9938041	-0,179987
25	R44	Misinformation on the container location	0,9905547	-0,183236
26	R42	Spreader ASC hit stacked container	0,9787048	-0,195086

Table 4. 35 Risk Ranking based on (D + R) and (D – R) calculation (con't)

Rank	Code Risk	Potential Risk	D+R	D-R
27	R29	Truck hits booth	0,927446	-0,246345
28	R21	Vehicle is damaged	0,9267835	-0,247008
29	R22	Property is damaged	0,9165096	-0,257281
30	R25	Trailer lifted	0,9149709	-0,25882
31	R43	Wrong mapping	0,914734	-0,259057
32	R41	ASC from water side hit ASC from land side	0,8952426	-0,278548
33	R31	Miscommunication between driver and operator	0,8804588	-0,293332
34	R19	Truck hits another truck	0,8775703	-0,296221
35	R23	Truck hits concrete barrier	0,8705285	-0,303263
36	R15	Crane is collapsed	0,812128	-0,361663
37	R10	Careless handling by the employee	0,7606753	-0,413116
38	R14	The system is error	0,7336638	-0,440127
39	R54	Mechanic is wedged	0,6586638	-0,515127
40	R55	Hit by vehicle	0,6586638	-0,515127
41	R56	Exposed to dangerous material	0,6586638	-0,515127
42	R47	Mechanics poisoned	0,644188	-0,529603
43	R48	Mechanic got electric shocked	0,644188	-0,529603
44	R50	Air tube explode	0,644188	-0,529603
45	R51	Mechanic slipped	0,644188	-0,529603
46	R52	Mechanic touched oil	0,644188	-0,529603
47	R53	Mechanic fall down	0,644188	-0,529603
48	R49	Mechanic is crushed	0,6324149	-0,541376
49	R12	Container is dropped in the wrong block	0,6132522	-0,560539
50	R24	Air pollution	0,5868955	-0,586896
51	R26	Twistlock is not working	0,5868955	-0,586896
52	R28	ID Card are unidentified	0,5868955	-0,586896

Source: Author's document

Note :

Dispatcher

Receiver

From the calculation of (D + R), it can be seen that R9, damaged tools and equipment, is on the first place with the score of 1,9450282 means this risk has the most relationship with other risk. For the last place is filled by R28, ID card are unidentified with the score of 0,5868955 means this risk has the least relationship with other risk.

From the calculation of (D – R), it can be seen that R9, damaged tools and equipment, is also on the first place with the score of 0,7712371 means this riskis affected most of the other risk, whilst the last place is filled by R28, ID card are unidentified with the score of -0,586896 which means this risk is mostly affected by other risk. When the score of (D – R) is positive, that means it is affecting other risk. On the other hand, when the score of (D – R) is negative, that means it is affected by other risk.

4.8.5 Impact Diagraph Map

To make the impact diagraph map, the value in the x-axis and y-axis is determined from the calculation of (D + R) and (D – R), in which x-axis is derived from (D + R) score and y-axis is derived from (D – R) score. The calculation of x-axis and y-axis is done using Microsoft Excel software.

Code Risk	D+R	D-R
R3	1,224643305	0,7712371
R4	1,5921337	0,4183426
R5	1,33610935	0,3125236
R6	1,179810244	0,2580737
R7	1,252694153	0,1623183
R8	1,167573078	0,1269154
R9	1,945028168	0,0876969
R10	0,760675304	0,0789031
R11	1,431864742	0,0508522
R12	0,613252234	0,0060192
R14	0,733663773	-0,006218
R15	0,812127987	-0,007272
R16	1,082110647	-0,047856
R17	1,012137817	-0,048182
R18	1,012137817	-0,048182
R19	0,877570328	-0,048182
R20	1,261487988	-0,048182
R21	0,926783455	-0,09168
R22	0,916509574	-0,119292
R23	0,870528459	-0,154952
R24	0,586895531	-0,15672

Figure 4. 28 Determination of x-axis and y-axis score
Source: Author's document

After the x-axis and y-axis is determined, impact diagraph map is made based on coordinate points of each risk.

4.9 Risk Mitigation Formulation

In order to determine the strategy of handling the risks, author design a plan to handle all of the risks. But, the priority to the risk is needed to be considered since not all risks can be mitigated with the best way to minimize cost. The criterias to consider a risk as a priority is listed below.

1. Risk that fall in the red zone (high risk) in the risk mapping

The risk that is mapped in the red area, or high risk, can be seen on Figure 4.18 and Table 4.10. These risks are prioritized to be mitigated due to the result of multiplication between occurence, severity, and detection score.

All the risk that also related to the human injury and death is also considered as high risk as requested by Terminal Teluk Lamong.

2. Risk that is categorized as dispatcher

The risks that categorized as dispacther means that those risks also become a cause for another risks to happened. Dispatcher risks can be seen in Table 4.10 in which 10 risks are identified as dispatcher risks.

Since all of these dispatcher risks have the value of (D + R) more than one, then it can be considered as affecting more risks than other, so all of these 10 risks are included to be priority.

Hence, the risks that fulfill either of the requirements mentioned above is the priority. Below is the list of prioritized risks.

Table 4. 36 Priority Risk

Code Risk	Potential Risk	Risk Category	Risk Correlation Type
R3	Container is not suitable to the standard	Low	Dispatcher
R4	Trucks tardiness	Low	Dispatcher
R5	System filter is not working	Low	Dispatcher
R6	System filter is not matched with the condition (container size, container types, destination, container weight)	Low	Dispatcher
R7	The scheduling system is error	Low	Dispatcher
R9	Damaged tools and equipment	Low	Dispatcher
R11	Container cannot enter container yard	Low	Dispatcher
R20	Injury to death	High	Dispatcher
R30	Network malfunction	Low	Dispatcher
R35	Container stack is collapsed	High	Receiver
R39	ASC spreader stuck to the container	High	Receiver
R41	ASC from water side hit ASC from land side	High	Receiver
R42	Spreader ASC hit stacked container	High	Receiver
R47	Mechanics poisoned	High	Receiver
R49	Air tube explode	High	Receiver
R50	Mechanic slipped	High	Receiver
R51	Mechanic touched oil	High	Receiver

Table 4. 37 Priority Risk (con't)

Code Risk	Potential Risk	Risk Category	Risk Correlation Type
R52	Mechanic fall down	High	Receiver
R53	Mechanic is crushed	High	Receiver
R54	Mechanic is wedged	High	Receiver
R55	Hit by vehicle	High	Receiver
R58	Power outage	High	Receiver
R59	Container is fall of ASC	High	Dispatcher

Table 4.13 shows that even though a risk is categorized as dispatcher using DEMATEL method, it is categorized as low risk in the risk mapping, such as R3, R4, R5, R6, R7, R9, R11, and R30. Meanwhile, even though a risk is categorized as high risk in the risk mapping, it is actually a receiver in the DEMATEL method, such as R35, R39, R41, R42, R47, R49, R50, R51, R52, R53, R54, R55, and R58.

But, as discussed with Terminal Teluk Lamong, all risks that has high score using FMECA (big impact, high probability, hard to detect) and a root cause of other risks to happened (dispatcher) has to be handled well to reduce the overall accident that may happen in the future.

As stated by Terminal Teluk Lamong, risk mitigation is the action to handle risk by reduce the occurence or the severity. In the risk management of Terminal Teluk Lamong, the risk treatment will be divided into four: risk avoidance; risk mitigation; risk transfer; and risk acceptance. There is a probability a risk will be treated with two methods.

Below is the risk treatment planning created by author relater to Automatic Stacking Crane Terminal Teluk Lamong.

Table 4. 38 Treatment to each risks

Risk Code	Potential Risk	Risk Mitigation			
		Accept	Avoid	Transfer	Mitigate
R3	Container is not suitable to the standard	Cross check with the agent shipping			Pamflet, brochure, and other media to give information to customer
R4	Trucks tardiness	Cross check with driver	Have the customer to build a block near the port		• Build intermode transportation • Build fly over
R5	System filter is not working	Manual check by operators			Maintain system periodically
R6	System filter is not matched with the condition (container size, container types, destination, container weight)	Manual check by operators			Maintain system periodically
R7	The scheduling system is error	Manual check by operators			Maintain system periodically
R8	Wrong input for schedule	Manual check by operators			
R9	Damaged tools and equipment		Prepare secondary equipment	Equipment insurance	Maintain equipment
R10	Careless handling by the employee			Equipment insurance	Train employee Control by supervisor
R11	Container cannot enter container yard				Inspect container before enter port
R12	Container is dropped in the wrong block	Cross check between operators and driver			• Put up sign • Draw up line in road

Table 4. 39 Treatment to each risks(con't)

Risk Code	Potential Risk	Risk Mitigation			
		Accept	Avoid	Transfer	Mitigate
R14	The system is error	Manual check by operators			Maintain system periodically
R15	Crane is collapsed			Equipment insurance	• Maintain and inspect ropes and crane • Algorithm maintenance
R16	Wire sling snapped	Change wire sling when it is snapped	Change wire sling periodically	Equipment insurance	• Maintain and inspect wire sling and crane
R17	Misinformation	Cross check before any activity			
R18	Wrong schedule	Cross check before any activity			
R19	Truck hits another truck			• Equipment insurance • Life insurance	• Give safety induction and test to all driver • Install CCTV and control all movement via CCTV • Create Moving Equipment Procedure and implement it • Instruct all driver to follow Traffic Road and and Pedestrian Procedure • Implement OH Procedure • Perform MCU periodically • Apply OSH Inspection Procedure • Assign Safety Patrol Procedure • Assign Safety Post Procedure • Maintain lights

Table 4. 40 Treatment to each risks(con't)

Risk Code	Potential Risk	Risk Mitigation			
		Accept	Avoid	Transfer	Mitigate
R20	Injury to death			Life insurance	• Instruct all human in the workship, container yard, and dwarft to use protective personnel equipment • Give safety induction and test to all employees • Install CCTV and control all movement via CCTV • Train all employees and driver
R21	Vehicle is damaged			Equipment insurance	• Create Moving Equipment Procedure and implement it • Implement OH Procedure • Perform MCU periodically • Maintain lights
R22	Property is damaged			Equipment insurance	• Create Moving Equipment Procedure and implement it • Implement OH Procedure • Perform MCU periodically • Maintain lights

Table 4. 41 Treatment to each risks(con't)

Risk Code	Potential Risk	Risk Mitigation			
		Accept	Avoid	Transfer	Mitigate
R23	Truck hits concrete barrier			• Equipment insurance • Life insurance	• Give safety induction and test to all driver • Install CCTV and control all movement via CCTV • Create Moving Equipment Procedure and implement it • Instruct all driver to follow Traffic Road and and Pedestrian Procedure • Apply OSH Inspection Procedure • Assign Safety Patrol Procedure • Assign Safety Post Procedure
R24	Air pollution	• Install air quality monitor			• Plant trees • Release environment intiatives
R25	Trailer lifted	Double check twistlock before container lifted			Install camera to see the twistlock
R26	Twistlock is not working		Change twistlock periodically		Inspect twistlock
R28	ID Card are unidentified		Change card periodically		• Card maintenance • Machine maintenance

Table 4. 42 Treatment to each risks(con't)

Risk Code	Potential Risk	Risk Mitigation			
		Accept	Avoid	Transfer	Mitigate
R29	Truck hits booth			Equipment insurance	• Give safety induction and test to all driver • Install CCTV and control all movement via CCTV • Create Moving Equipment Procedure and implement it • Instruct all driver to follow Traffic Road and and Pedestrian Procedure • Apply OSH Inspection Procedure • Assign Safety Patrol Procedure • Assign Safety Post Procedure
R30	Network malfunction	Manual check by operators	Have second network with backup		Maintain system periodically
R31	Miscommunication between driver and operator	Double check before an activity is done			
R32	The sensors are error		• Change sensors periodically • Change sensor when broken	Equipment insurance	• Maintain and inspect sensors • Algorithm maintenance
R35	Container stack is collapsed			Equipment insurance	

Table 4. 43 Treatment to each risks(con't)

Risk Code	Potential Risk	Risk Mitigation			
		Accept	Avoid	Transfer	Mitigate
R36	Incorrect number of stacked container	Manual control			Maintain algorithm
R37	Container stack is tilted	Manual control			Maintain algorithm
R38	Container stuck	Manual control		Equipment insurance	
R39	ASC spreader stuck to the container	Manual control		Equipment insurance	Inspect ASC spreader periodically
R40	Container's content is spilled	Manual control		Equipment insurance	
R41	ASC from water side hit ASC from land side	Manual control		Equipment insurance	Maintain algorithm
R42	Spreader ASC hit stacked container	• Manual control • Check if any tier is higher than it should be (max. 5)		Equipment insurance	
R43	Wrong mapping	Double check on mapping	Any mapping is given to planner		
R44	Misinformation on the container location	Double check on the container location between ASC operators and planner			
R45	Wrong input for place	Cross check location input before any submission			

Table 4. 44 Treatment to each risks(con't)

Risk Code	Potential Risk	Risk Mitigation			
		Accept	Avoid	Transfer	Mitigate
R46	Land contamination				• Primary shelter • Release environment initiatives • Train employees not to destroy, spill, etc the dangerous materials
R47	Mechanics poisoned		Apply Isolation and lock down procedure	Life insurance	• Powder, saw, and bucket ready • Get trash bin ready • Get absorbent ready • Apply Exhaustion Control Procedure • Set 5S • Set SOP for working on heights • Maintenance for maintenance equipment • Using full body hearness with shock absorber • Sticker for dangerous material and equipment

Table 4. 45 Treatment to each risks(con't)

Risk Code	Potential Risk	Risk Mitigation			
		Accept	Avoid	Transfer	Mitigate
R48	Mechanic got electric shocked		Apply Isolation and lock down procedure	Life insurance	• Apply Exhaustion Control Procedure • Set 5S • Set SOP for working on heights • Maintenance for maintenance equipment • Using full body hearness with shock absorber • Apply Electricity Safety Procedure • Install appropriate lights • Install barricade
R49	Air tube explode	• Have APAR thematic ready			• Maintain and inspect on compressor • Change ring and clamp periodically • Avoid any fire near air tub • Powder, saw, and bucket ready • Get trash bin ready • Get absorbent ready • Apply Exhaustion Control Procedure • Set 5S • Set SOP for air tube

Table 4. 46 Treatment to each risks(con't)

Risk Code	Potential Risk	Risk Mitigation			
		Accept	Avoid	Transfer	Mitigate
R50	Mechanic slipped		• Build platform and railing for activities not on land • Apply Isolation and lock down procedure	Life insurance	• Get trash bin ready • Get absorbent ready • Apply Exhaustion Control Procedure • Set 5S • Set SOP for working on heights • Maintenance for maintenance equipment • Using full body hearness with shock absorber • Install appropriate lights
R51	Mechanic touched oil		Apply Isolation and lock down procedure	Life insurance	• Get absorbent ready • Apply Exhaustion Control Procedure • Set 5S • Set SOP for working on heights • Maintenance for maintenance equipment • Using full body hearness with shock absorber • Install appropriate lights

Table 4. 47 Treatment to each risks(con't)

Risk Code	Potential Risk	Risk Mitigation			
		Accept	Avoid	Transfer	Mitigate
R52	Mechanic fall down		• Build platform and railing for activities not on land • Apply Isolation and lock down procedure	Life insurance	• Change wire rope periodically • Turn off MCB and install tag and lock out • Get absorbent ready • Apply Exhaustion Control Procedure • Set 5S • Set SOP for working on heights • Using full body hearness with shock absorber • Install safety net • Put up signs if there is a work being done • Install appropriate lights
R53	Mechanic is crushed		• Build platform and railing for activities not on land • Apply Isolation and lock down procedure	Life insurance	• Change wire rope periodically • Turn off MCB and install tag and lock out • Apply Exhaustion Control Procedure • Set 5S • Set SOP for working on heights • Maintenance for maintenance equipment • Using full body hearness with shock absorber • Using tag line on the equipment to steer it • Put up signs if there is a work being done • Install appropriate lights

Table 4. 48 Treatment to each risks(con't)

Risk Code	Potential Risk	Risk Mitigation			
		Accept	Avoid	Transfer	Mitigate
R54	Mechanic is wedged		• Build platform and railing for activities not on land • Apply Isolation and lock down procedure	Life insurance	• Change wire rope periodically • Turn off MCB and install tag and lock out • Secondary shelter • Powder, saw, and bucket ready • Get trash bin ready • Get absorbent ready • Apply Exhaustion Control Procedure • Set 5S • Set SOP for working on heights • Maintenance for maintenance equipment • Using full body hearness with shock absorber • Using tag line on the equipment to steer it • Put up signs if there is a work being done • Install appropriate lights

Table 4. 49 Treatment to each risks(con't)

Risk Code	Potential Risk	Risk Mitigation			
		Accept	Avoid	Transfer	Mitigate
R55	Hit by vehicle		No human may pass certain area if a maintenance is being conducted	Life insurance	• Give safety induction and test to all driver • Install CCTV and control all movement via CCTV • Create Moving Equipment Procedure and implement it • Instruct all driver to follow Traffic Road and and Pedestrian Procedure • Apply OSH Inspection Procedure
R56	Exposed to dangerous material			Life insurance	• Secondary shelter • Powder, saw, and bucket ready • Get absorbent ready • Apply Exhaustion Control Procedure • Set 5S • Set SOP for working on dangerous materials • Using full body hearness with shock absorber • Put up signs if there is a work being done

Table 4. 50 Treatment to each risks(con't)

Risk Code	Potential Risk	Risk Mitigation			
		Accept	Avoid	Transfer	Mitigate
R58	Power outage		Build LNG power plant		
R59	Container is fall of ASC				• Maintain twistlock in the spreader • Maintain spreader • Maintain algorithm

Source: Author's document

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CHAPTER 5
DATA ANALYSIS AND INTERPRETATION

This chapter will explain the analysis and interpretation of data collected and processed in previous chapter.

5.1 Analysis of Risk Management Implementation at Terminal Teluk Lamong

Terminal Teluk Lamong, as their goals is to be the top five green port, implement all of the international standard to their business process, no exception for risk management. Terminal Teluk Lamong choose ISO 31000:2009 framework to arrange risk management planning.

From the discussion with Terminal Teluk Lamong QHSSE department, they already establish a risk management report for the company. The report consists of the methodology they use from the planning result of Corporate Risk Masterplan Management Plan at Terminal Teluk Lamong based on area, equipments, director order and standard operational procedure. In fact, Terminal Teluk Lamong also include Automatic Stacking Crane as one of the equipment to be risk-managed in their company risk management report. But, as it can be seen in chapter 4, in total there are only 6 risk identified by the company. This is caused by the risk identification is done improperly. For now, Terminal Teluk Lamong established the responsibility of each stakeholder related to the risk management, such as who is the risk agent, and what kind of person is identified as risk owner. The other reason is the risk management for Automatic Stacking Crane, until now, are established only for formality. Differ with other equipment, Automatic Stacking Crane is a relatively new equipment in Indonesia. It is become a challenge for Terminal Teluk Lamong to be example of other ports that in the future may use Automatic Stacking Crane in their business process.

The management at Terminal Teluk Lamong also realized there are several accidents happened that cost the company. Not only costly, but also the judgment from international customers makes Terminal Teluk Lamong decides to establish a detail, well-established risk management for Automatic Stacking Crane.

Although, Terminal Teluk Lamong has a dashboard risk profile in the shape of Microsoft Excel document and update it every year, together with the company report. This is one step further than any other port. Let alone the fact that their risk agents, General Manager, also bestow his/her tasks so each equipment can be watched carefully.

5.2 Analysis of Activities Related to Automatic Stacking Crane

Automatic Stacking Crane is an equipment used by Terminal Teluk Lamong to move containers in the container yard. Container yard is the place in which containers are stacked before it is taken to the ship or customer trucks. In this research, the risk management is focused to the activities related to the operation of Automatic Stacking Crane. There are total of 22 processes from 5 flow chart. The processes are summaried from the system procedures that Terminal Teluk Lamong published for their employees.

The first process is taking place in the control room, for planner. There are total three activities: customer order verification; scheduling process; and scheduling input. Even though the person in charge of these activities are planner, what kind of decision that is taken by them will affect the operational activities of ASC. There is a possibility that when this process is not executed well, the operational activities will have a lot of unnecessary interruption.

The second and third process is related to CTT. CTT is the vehicle that will bring container from the container yard to and from the docks. There are in total six activities: ship unloading; container movement from dock to WSTA; container is dropped in ASC block; request to take container; container movement from container yard to WSTA; and container movement from WSTA to the dock. The activities is counted as related to ASC due to the fact that the first place the container have to be after unloaded from the ship is container yard, and to get into container yard, they use ASC.

The fourth process is related to trucks. Customers' truck drop or take the container out of container yard via its LSTA side. There are in total 8 activities: truck enter ASC block; twistlock chasis opening by truck driver; booth confirmation by driver swap ID; communication between driver and ASC operator; lift on/off process using ASC; stack container in container yard; bring container to place other than container yard; and container location confirmation by ASC operators. Since the process to get a container get out of the port has to involve customers' truck, this is also an important process related to ASC.

The fifth process is maintenance. There are five activities related to maintenance: refill oil; replace hose line; replace electric motor; replace electrical installation; and automatic stacking crane inspection. The maintenance of ASC has a different timeline, some are daily, some are weekly. Nevertheless, it is important because if the maintenance is not done, the ASC could be get down easily.

In this research, not only the process in ASC that is included, but also the process related to the process continuity such as planner, container move in – move out from container yard to the docks, and trucks. When a planner schedule a container without any consideration and calculation, there is a possibility that the space is not available for the container enter the container yard when it is time. It will damage Terminal Teluk Lamong reputation in the eye of customers. Another example, if truck driver communication with ASC operator is not working well, there will be some miscommunication between them, may cause an accident for the container and driver, affect the whole loading and unloading process. This shows that other activities outside container yard also affect ASC operations.

5.3 Analysis of Risk Identification to Automatic Stacking Crane Operation Process

From the experience, all of the respondents is working in their job for more than four years. All of the respondents is chosen based on their job description, since their job is related to ASC operational activities. So, they are fit to be chosen as respondents since they have an experience in their work and their field is suitable for the problem in this research.

Table 5. 1 Respondents job description

No	Title	Job Description
1.	QHSSE Employee	• Make sure quality of business process work well • Release SOP, environment, and safety initiatives • Risk agent • Coordinate all safety work • In charge of insurance
2.	Shift Manager	• Control container yard • Control all activities on control room • Make decision related to loading/unloading process • Coordinate all employees in control room

Table 5. 2

No	Title	Job Description
3.	ASC Operator	• Lift on/off container from truck • Lift on/off container from container yard • Follow placement of container set by planner • Communicate with driver
4.	Planner	• Verify containers and slot in the container yard • Schedule trucks arrival

No	Title	Job Description
		• Schedule CTT arrival • Confirm slot to agent shipping • Deliver schedule to ASC operator
5.	Technical and Engineering	• Control the equipments in the work shop • Plan the maintenance for equipments • Design the workshop • Control all the movement and works on the equipment in the work shop and container yard

Source: Author's document

Table 5.1 shows that all of the respondents has a responsibility to the process in container yard, or in this context, Automatic Stacking Crane. So, all of the respondents is considered as experts in their own field, since a process is well-known by one person, but not another, so all of the respondents is needed to complete the risk identification.

In Delphi Questionnaire Round 1, it is known that respondents understand risk management is applied in the use of ASC. However, they all agree that there is a need to extensively the risk management. The operator and planner do not know that Terminal Teluk Lamong is using ISO 31000:2009 as their framework for risk management, but they know international framework is used. It is also known there are total 52 potential risks identified for operational activities related to ASC. Then, all of these potential risks is scored by respondents in Delphi Questionnaire round 2.

In Delphi Questionnaire Round 2, all of the potential risks is scored using Likert scale. As a result, all of the risks have a mean and standard deviation that say the respondents agree with the potential risks. Although, there are total 3 potential risks crossed out from the list after the discussion with QHSSE department as the risk agent because they think that Terminal Teluk Lamong is not the risk owner of the risks.

The problem in this case is the respondents still needs some discussion even after given the questionnaire. For example, one statement feel just like another statement written later, but the fact is the respondents give a different risk, just not articulate it better in written statement. As the Delphi Questionnaire is move around, author still need to verified every statement in the questionnaire to the respondents to make sure the implication of the statement is caught on right. This is probably caused by the fact that author is dealing with

employees that are working in the field, so the effectiveness of this method is not effective as it should be. Author also used historical data of accidents to identify potential risks.

In total, there are 56 risks identifies, 96 if the repetitive one is counted. Since all the risks is known now, the next step is to assess the risk.

5.4 Analysis of Potential Risks related to Automatic Stacking Crane Operational Activities

After all of the potential risks is determined, the next step is identifying the severity or potential effect if the risks is occured, occurence or risk cause of a risk event, and detection or existing current control. Because, risk event is uncertain and if it is happen, the activities will be failed to be done

Identification process for potential effect, risk cause, and current control is substantial to the research to know how severe a risk if it's happened, how often, and if it is easy to detect if there is any problem. To identify, author first processed all of accident history and log book to know how Terminal Teluk Lamong handle a problem. Observation and focus group discussion is also conducted with risk agent and risk owner in Terminal Teluk Lamong, which are QHSSE employee and technical and engineering employee, since they already know their way around ASC.

As a result, many of the potential effect and risk cause can be identified. All of the potential risks is also already have existing current control. However, Terminal Teluk Lamong agrees that it is still insufficient, so the formulation of current control is needed.

5.5 Analysis of Potential Risk Scoring of Automatic Stacking Crane Operational Activities

5.5.1 Analysis of Severity, Occurence, and Detection Score Determination

Severity, Occurence, and Detection score is determined by Head of Operation, Head of Automatic Stacking Crane Operation, and Head of Maintenance. The recapitulation result then is averaged for each potential risks.

Severity scoring purpose is to measure the loss if a risk event occur. The higher the score of severity, the higher loss that could happen. The criteria of severity score is using Likert scale with 1 to be insignificant and 5 to be catasthropic.

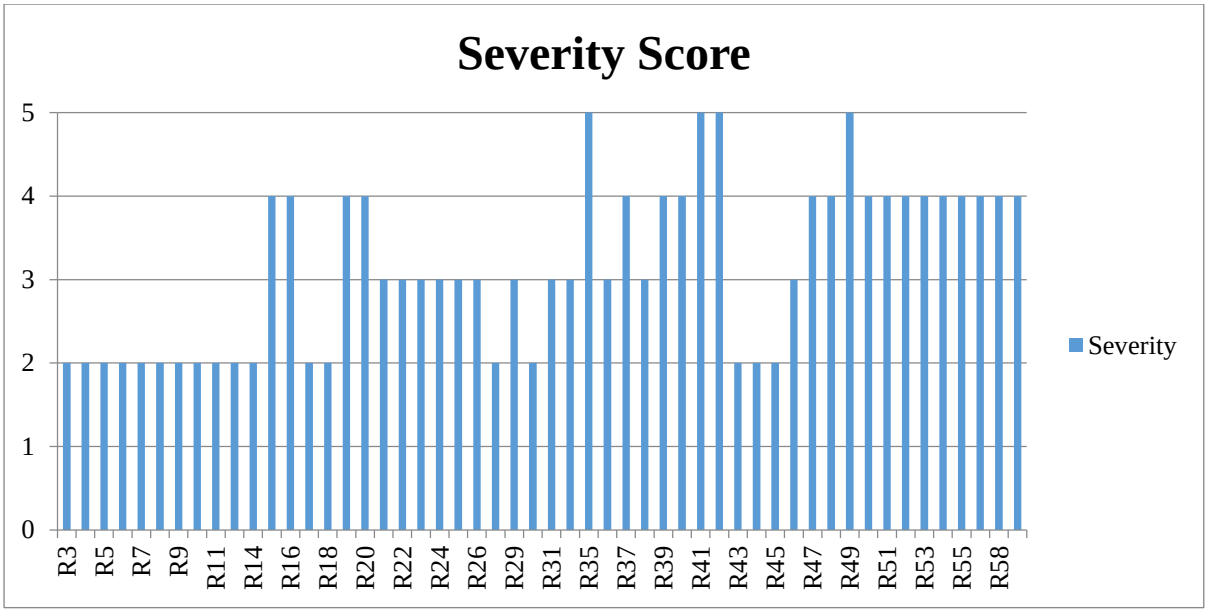

Figure 5. 1 Recapitulation of severity score
Source: Author's document

Based on the recapitulation of severity score, it can be seen that the highest severity is 5 for R35, R41, R42, and R49. Generally, the severity score for potential risk in Automatic Stacking Crane in the score of 2 and 3. Based on the score that is made by Terminal Teluk Lamong, severity score in the span 2 and 3 means minor and moderate consequence if the risk is happpened. Since it is not insignificant, the risks need to be handled. If all of the risks happened in the same time, the consequences will be ill.

Occurence scoring purpose is to measure a possibility of a risk event occur. The higher the score of occurence, the higher is the likelihood of the risk event. More often a risk cause happened, higher the occurence. Criteria of occurence score is using Likert scale with 1 to be rare and 5 to be almost certain. The figure below show the recapitulation of occurence score from the questionnaire.

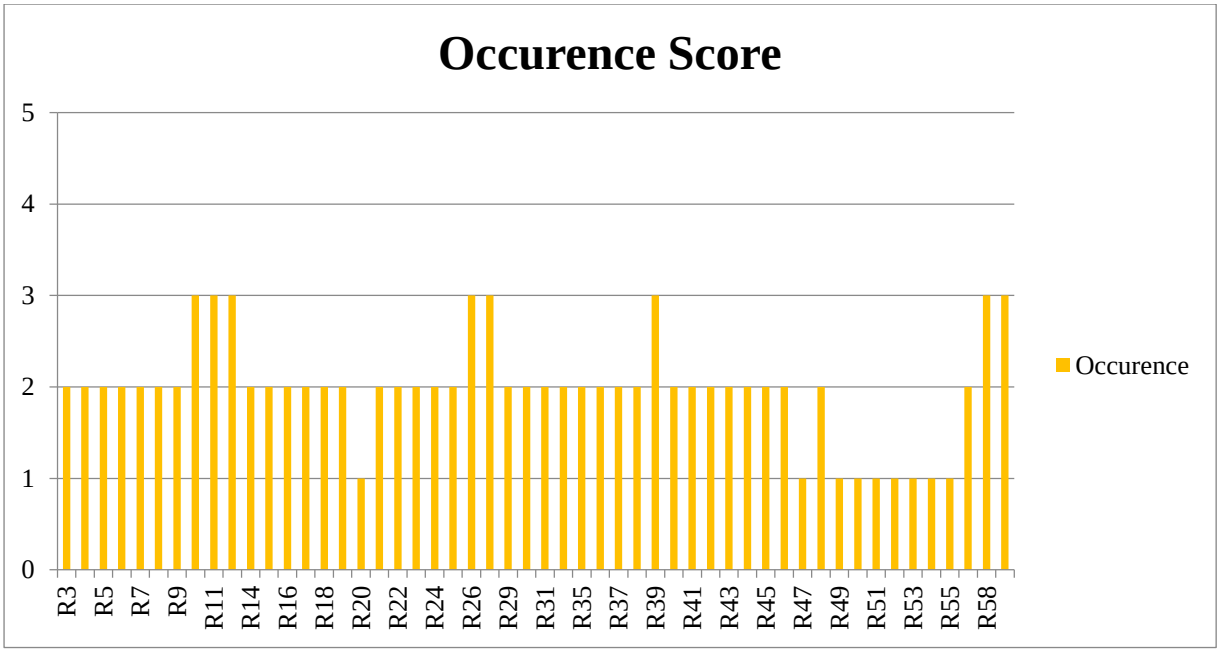

Figure 5. 2 Recapitulation of occurence score
Source: Author's document

From the figure above, the highest score is only 3, for R10, R11, R12, R26, R28, R39, R58, and R59. Even though the score in the severity is pretty high, the majority occurence score is only 2. This is caused by the fact that these incidents actually not happen everyday. In a year, that is a probability of a risk happened 4 – 6 times, according to the incident report had by Terminal Teluk Lamong. But, the problem is, Automatic Stacking Crane in Terminal Teluk Lamong only operatod for 10 blocks, and in the master plan for port facilities, in 2020 should be realized around 20 - 30 blocks of Automatic Stacking Crane. So, it is important in the future to update the score of occurence.

Detection scoring purpose is to measure the possibility that a risk event is detected before it could happen. The higher the detection score, the higher possibility the risk is not detected right away. Criteria of detection score is using Likert scale with 1 to be effortless detection and 5 to be detection failure after inspection. Terminal Teluk Lamong released the current control that acts not only as mitigation, but also to detect the risk before it happened. Below is the recapitulation of detection score.

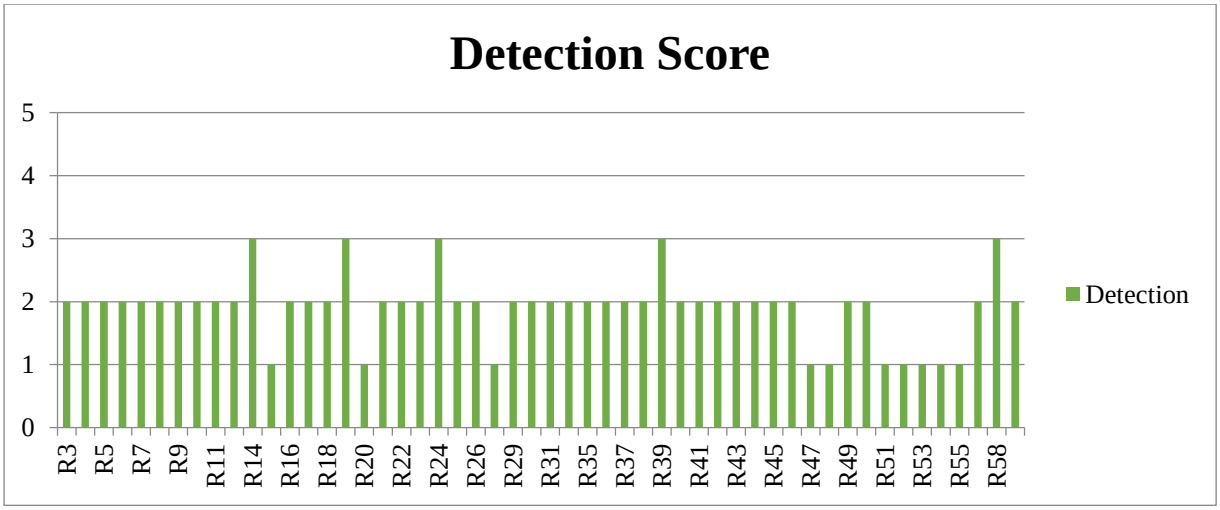

Figure 5. 3 Recapitulation of detection score
Source: Author's document

From the detection score, it can be seen all of the risk is considered as, at least, detected if full maintance is performed. The highest score is 3. Nevertheless, to detect and to mitigate the risk, the current control is no longer sufficient since the number of accident related to Automatic Stacking Crane is increasing over the years.

5.5.2 Analysis of Risk Priority Number Determination

After the score of severity, occurence, and detection is obtained, the risk priority number (RPN) can be calculated. It is obtained from the multiplication of severity, occurence, and detection score.

The highest risk priority number is 36, for R39, ASC spreader stuck to the container, and R58, power outage.

RPN score shows the priority of risk handling. If a potential risk has a high severity, occurence, and detection socre, it means the risks has a big impact, higher frequency, and har detection occurence of occurence. It could cause a big loss for Terminal Teluk Lamong, from stopping the loading unloading event, until disaster accident.

5.5.3 Analysis of Risk Mapping

Other than RPN score, priority of risk is also determined by risk mapping. Risk mapping is done by grouping the risks into four level of categories, which are high, medium, low, and very low. The risk mapping is done based on two risk assessment, severity and

occurence. Even thought the occurence is low but the severity is high, the risk is still categorized as high since if it happened, the loss will be huge.

The total of risk categorized as high is 15, medium is 8, and low is 29. Half of the potential risks need to be mitigated right away, for high and medium categorized. It is in the interest of Terminal Teluk Lamong to reduced all of the risk at least medium by mitigation.

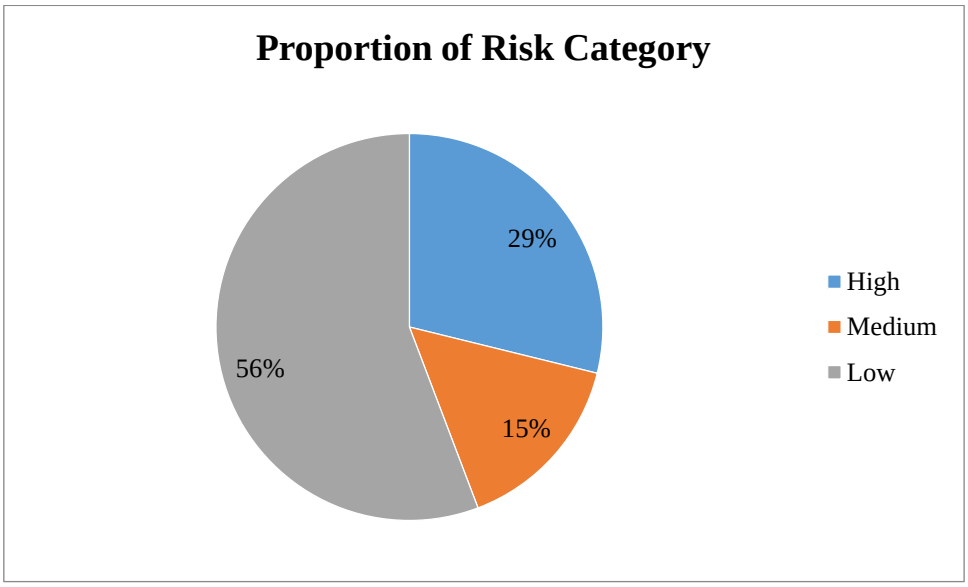

Figure 5. 4 Proportion of risk category
Source: Author's document

The risk mapping criteria is given by Terminal Teluk Lamong, as they get the scores formulated by PT Pelindo 3 as its parent company. Different from the FMECA usual risk mapping, there are four level of risk category in this risk map. From the interview with Terminal Teluk Lamong, this is caused by the desire of PT Pelindo 3 for all of its subsidiary company to treat the risk as they should be treated. The low category is divided into two, very low and low, whilst the medium that usually has larger area, reduced into three.

The Likert scale of severity, occurence, and detection of the risk is also ranged from 1 to 5. In the opinion of author, there should be an extention of range to be 1 to 10 to have a better perspective and more detailed score of risks. Then, for the risk level, it is better still to have only 3 level since the low and very low area become larger and it is feared to make a risk looks like a low event but in reality it is not.

5.6 Analysis of Automatic Stacking Crane Operational Activities Risk Correlation

The process to determine the risk correlation is using Decision Making and Trial and Evaluation Laboratory (DEMATEL) method. The correlation calculation goal is to measure the relationship of each risk to another. The higher the correlation, the higher the effect of a risk to make other risk happened. The correlation score is obtained from quetionnaire filled by expert which are Head of Operation, Head of Automatic Stacking Crane Operation, and Head of Maintenance.

In accordance with the criteria of assessment of the relationship between risks in DEMATEL method, author used scale 0 – 4 with a score of 0 means no effect and score of 4 means very high influence. From the result of the questionnaire, before the processing of the data, R24, air pollution, is the risk with no relationship at all with other risk and most affected by other.

After the data is processed, the dispatcher vector and receiver vector can be determined, illustrates the causation relation amongst risks. Dispatcher risk is the cause of other risk happened, while receiver risk is a the outcome. So, in the strategy formulation to treat risk for Automatic Stacking Crane, dispatcher risk is being priority. (D – R) value shows which risks most affecting other risks. Differs with the result of the questionnaire, the risk most affecting is R9, damaged tools and equipment. Meanwhile, the most affected risk is R28, ID card are unidentified.

Table 5. 3 Score of R9, damaged tools and equipment, effect to other risk

Code Risk	Potential Risk	Score
R3	Container is not suitable to the standard	1
R7	The scheduling system is error	2
R11	Container cannot enter container yard	1
R15	Crane is collapsed	3
R16	Wire sling snapped	4
R19	Truck hits another truck	2
R20	Injury to death	1
R21	Vehicle is damaged	2
R22	Property is damaged	2
R25	Trailer lifted	2
R29	Truck hits booth	2
R32	The sensors are error	4
R35	Container stack is collapsed	1
R36	Incorrect number of stacked container	2
R37	Container stack is tilted	2

Table 5. 4 Score of R9, damaged tools and equipment, effect to other risk (con't)

Code Risk	Potential Risk	Score
R38	Container stuck	1
R39	ASC spreader stuck to the container	1
R41	ASC from water side hit ASC from land side	3
R42	Spreader ASC hit stacked container	3
R43	Wrong mapping	1
R44	Misinformation on the container location	1
R46	Land contamination	2
R47	Mechanics poisoned	2
R48	Mechanic got electric shocked	2
R49	Air tube explode	2
R50	Mechanic slipped	2
R51	Mechanic touched oil	2
R52	Mechanic fall down	2
R53	Mechanic is crushed	2
R54	Mechanic is wedged	2
R55	Hit by vehicle	2
R56	Exposed to dangerous material	2
R58	Power outage	3
R59	Container is fall of ASC	4

Source: Author's document

From Table 5.2, it can be seen that if an equipment or tools is damaged, about 34 other risks is affected. For example, if an equipment or tools is damaged, it can make R15, crane is collapsed, realized in the future. If a crane is collapes, R20, Injury or death, could happened. This is why R9 become the priority of the risk to be mitigated, before it snowballing to make lots of accident happen in the container yard.

Other output from DEMATEL method is impact diagraph map that show risk that most affecting and most affect, in which x-axis is the value of (D + R) and y-axis is the value of (D – R). More positive a point in the x-axis, more relationship of that risk to another. So as more positive a point in the y-axis, more high the relationship of that risk to another.

5.7 Analysis of Strategy Formulation for Automatic Stacking Crane Operational Activities Risk Treatment

Strategy formulation for risk treatment is based on what risk that has to be handled. It can be seen in cub chapter 4.9 the criterias of risk to be priority, which are in the red areas on risk mapping (high risk) and the risk categorized as dispatcher. After collected, in total there are 15 risks categorized as high risk and 10 risks categorized as dispatcher. The criteria of

priority is mostly to know the critical risks and to know how to treat the risk. Meanwhile, the strategy formulation for automatic stacking crane operational activities will be for all risk identified in this research.

To formulate the strategy, author makes current control of each risks as one of the source to determine how to treat the risk. Other than that, author discuss with risk agent and risk owner ofTemrinal Teluk Lamong. As it is stated by Terminal Teluk Lamong guide for risk management, they have four treat for risk : risk avoidance (avoid risk by eliminate the cause of risk or the consequences); risk mitigation (find alternatives action to reduce the probability or consequences of the risk); risk transfer (transfer risk to other parties), or risk acceptance (accept potential risk and keep operate the process or implement a control method to reduce risk level to an accepted level). All of the method adjust to the available potential risk. One risk is possible to have more than one treatment. Below is the proportion of every rmitigation formed.

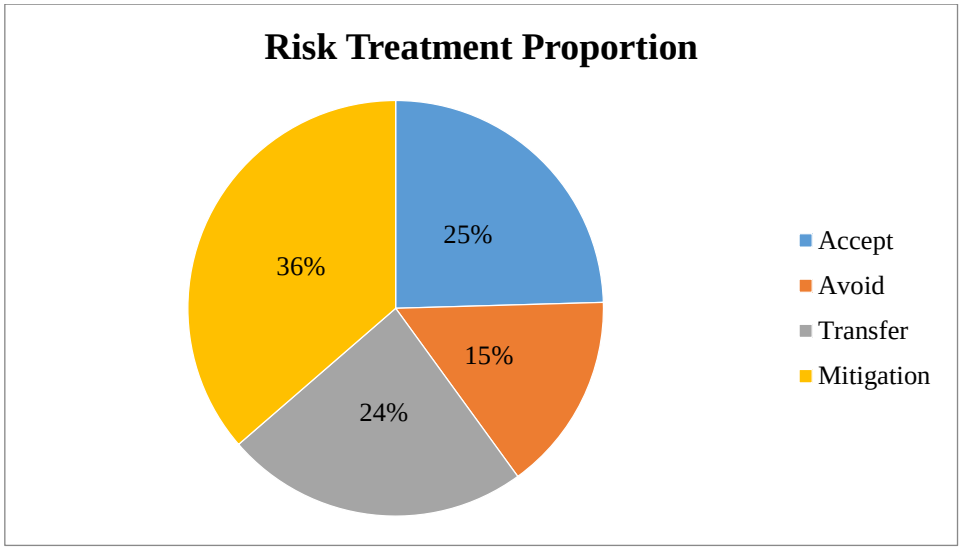

Figure 5. 5 Risk treatment proportion
Source: Author's document

From Figure 5.5 it can be seen that the most method being used is mitigation, since that most of the activities in the Automatic Stacking Crane is done sequentially, so if a risk is realized, it may affect the next activities. Terminal Teluk Lamong also insured all of their equipment. But, business interruption cannot be insured. That is why other method needs to be done, too.

Meanwhile, for avoid and accept risk, it is because the risk is seen as something that can be handled if the activity is done carefully and accurately.

CHAPTER 6
CONCLUSION AND SUGGESTION

6.1 Conclusion

1. Delphi Method has been used to identify the risks in this study that is related to the use of ASC in the port namely Terminal Teluk Lamong. The result showed a total of 59 potential risks. Three risks among those identified were excluded because the risk owner was not Terminal Teluk Lamong.
2. The risks scoring was performed using FMECA. Potential effects, causes, and current control for each risk were identified to get the estimate of risk priority number (RPN).
3. The risk mapping was performed based on the score of assessment in terms of severity and occurence. There were 4 categories in the risk map; high; medium; low; and very low risk. In total, there were 19 risks categorized as high , 7 medium, and 30 low risks.
4. Based on the result, it was confirmed that the risks in higher priority were also mapped into the high or medium category in the risk mapping.
5. The risk correlation analysis was performed using DEMATEL method. The result shows that 10 risks were categorized as dispatcher risk, which means that these risks would affect other risks to take place should they realize.
6. The mitigation towards potential risks were formulated based on the risk priority number, its current control, and the potential effect. The risk priority was based on the category of risk and the correlation of the risk with other risks. The chosen mitigation strategy was to transfer all of the risks to the insurance company. However, some effects will not be covered by the insurance company. Thus, the company has decided to develop additional mitigation plans to reduce the effects that cannot be be insured, such as business interruption.
7. All of the potential risks and the mitigation plans from this study were presented in the form established by Terminal Teluk Lamong.

6.2 Suggestion

6.2.1 Suggestion for Terminal Teluk Lamong

1. Terminal Teluk Lamong should use information system to store and manage their potential risk events and the mitigations so that they could be easily accessed by the employees. It will also allow them to be revised in the future whenever necessary.
2. Terminal Teluk Lamong should identify or renew their risks and score them periodically, mainly because the development of Terminal Teluk Lamong is not completed yet. Thus, some other risks that have not been identified and predicted in this study may occur in the future.

6.2.2 Suggestion for Future Research

1. Delphi method is not recommended for technical employees. It is better to use discussion (i.e. focused group discussion) or observation method.
2. The scale for FMECA method should be well analyzed and evaluated first before risk mitigation is formulated.

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ATTACHMENT

ATTACHMENT A

KUESIONER DELPHI – PUTARAN I

IDENTIFIKASI POTENSI RISIKO MANAJEMEN RISIKO UNTUK PERALATAN AUTOMATIC STACKING CRANE DI TERMINAL TELUK LAMONG DENGAN PENDEKATAN METODE DELPHI

Kuesioner ini bertujuan untuk melakukan identifikasi dan analisis mengenai potensi risiko pada seluruh aktivitas yang berhubungan dengan peralatan Automatic Stacking Crane di Terminal Teluk Lamong. Hasil kuesioner akan diolah lebih lanjut dan digunakan untuk kepentingan akademik (penelitian tugas akhir).

Perlu diketahui bahwa penelitian ini hanya dilakukan untuk PROSES OPERASI dari alat AUTOMATIC STACKING CRANE. Kuesioner berikut terdiri dari dua bagian, mohon Bapak/Ibu mengikuti petunjuk pada tiap-tiap bagian. Atas kerjasama dan kesediaan Bapak/Ibu dalam mengisi kuesioner, kami ucapkan terima kasih.

BAGIAN I

Petunjuk Pengisian : Jawablah pertanyaan di bawah ini dengan singkat dan jelas!

1. Apakah Automatic Stacking Crane di Terminal Teluk Lamong memiliki manajemen risiko untuk mengontrol aktivitas operasinya?
   Ya/Tidak*)

   Apabila ada, jelaskan sesuai dengan yang anda ketahui!
   ……..…….…….
   ……..…….…….
   ……..……

2. Apakah yang anda ketahui tentang standar framework risiko dari ISO, ISO 31000:2009?
   ……..…….……..…
   ……..…….……..…
   ……..…….
   ……..…….……

3. Apakah Automatic Stacking Crane di Terminal Teluk Lamong telah menerapkan sistem manajemen risiko sesuai ISO 31000:2009?
   Sudah/Belum*)

Apakah manfaat yang diberikan dari adanya penerapan sistem manajemen risiko berdasarkan ISO 31000:2009 pada aktivitas/pekerjaan Saudara?

……..…….…….
……..…….…….
……..…….…….
……..……

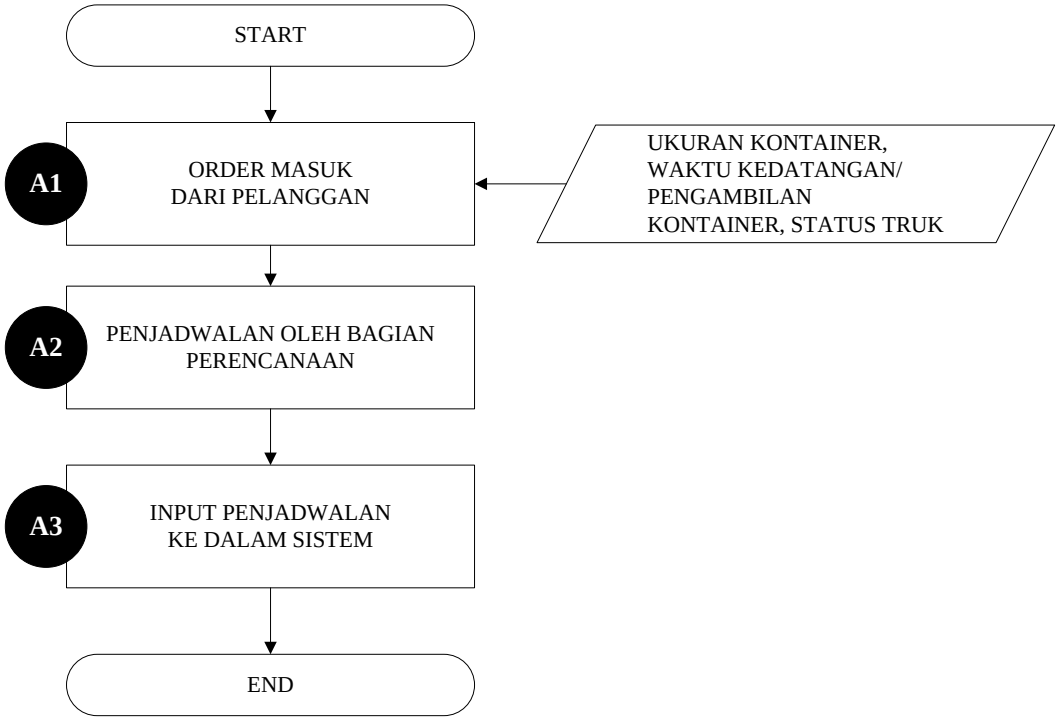
Apakah evaluasi dari sistem manajemen risiko di Terminal Teluk Lamong yang selama ini telah diterapkan?

……..…….…….
……..…….…….
……..…….…….
……..……

BAGIAN II

Petunjuk Pengisian : Isilah tabel berikut ini dengan risiko atau potensi risiko yang terjadi!

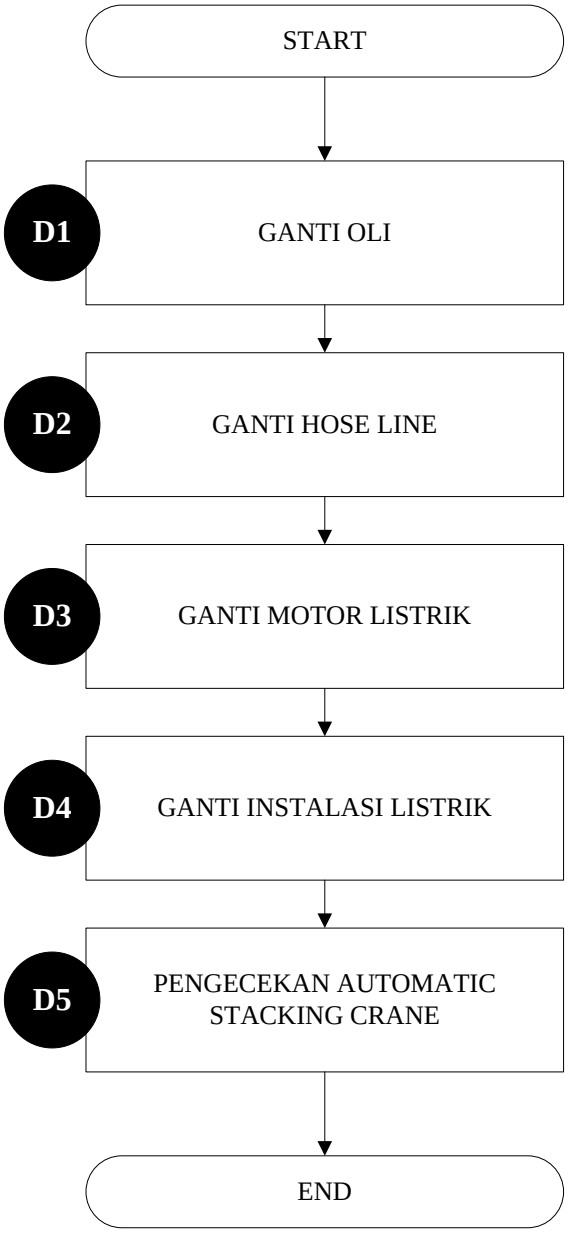
ALUR PERENCANAAN MASUK/KELUAR KONTAINER DARI LAPANGAN PENUMPUKAN



ALUR PENEMPATAN KONTAINER DI LAPANGAN PENUMPUKAN


START
C1
TRUK PARKIR DI LAPANGAN TUMPUK
C2
TRUK MENUNGGU PROSES DARI ASC
C3
PERPINDAHAN KONTAINER DARI TRUK KE LAPANGAN TUMPUK (LSTA)
C4
PERPINDAHAN KONTAINER DARI LAPANGAN TUMPUK (LSTA) KE CTT
C5
CTT MEMBAWA KONTAINER UNTUK MUAT KAPAL
END

ALUR PERAWATAN AUTOMATIC STACKING CRANE



Saudara diminta untuk menuliskan potensi-potensi risiko yang dapat terjadi pada setiap aktivitas diatas.

Contoh :

No	Kode Aktivitas	Potensi Risiko
1	E9	Penataan barang yang tidak sesuai karena kesalahan petugas
No	**Kode Aktivitas**	**Potensi Risiko**

No	Kode Aktivitas	Potensi Risiko

BIODATA RESPONDEN

Mohon Saudara berkenan untuk mengisi biodata responden yang bertujuan untuk pendataan biografi responden. Data ini akan dirahasiakan dan tidak disebarluaskan untuk kegiatan profit/komersil lainnya.

Nama : ……..……..
Jabatan : ……..……..
Mulai bekerja di RSI JS sejak : Bulan : ……..... Tahun : ……..…….....
Pendidikan : ……..……..
Bidang Studi/Keahlian : ……..……..
Nomor HP : ……..……..
Alamat Tinggal : ……..……..
……..……

Surabaya, …… Mei 2018

(…….....……)

ATTACHMENT B

KUESIONER DELPHI – PUTARAN II

IDENTIFIKASI POTENSI RISIKO MANAJEMEN RISIKO UNTUK PERALATAN AUTOMATIC STACKING CRANE DI TERMINAL TELUK LAMONG DENGAN PENDEKATAN METODE DELPHI

Kuesioner ini bertujuan untuk melakukan identifikasi dan analisis mengenai potensi risiko pada seluruh aktivitas yang berhubungan dengan peralatan Automatic Stacking Crane di Terminal Teluk Lamong. Hasil kuesioner akan diolah lebih lanjut dan digunakan untuk kepentingan akademik (penelitian tugas akhir).

Perlu diketahui bahwa penelitian ini hanya dilakukan untuk PROSES OPERASI dari alat AUTOMATIC STACKING CRANE. Kuesioner berikut terdiri dari dua bagian, mohon Bapak/Ibu mengikuti petunjuk pada tiap-tiap bagian. Atas kerjasama dan kesediaan Bapak/Ibu dalam mengisi kuesioner, kami ucapkan terima kasih.

RINGKASAN HASIL PUTARAN I

Pada kuesioner tahap I telah dilakukan penjaringan informasi mengenai penerapan sistem manajemen risiko di Terminal Teluk Lamong, didapatkan informasi Terminal Teluk Lamong menggunakan ISO 31000:2009 sebagai pedoman dalam menjalankan manajemen risiko perusahaan.

Adapun sistem manajemen risiko pada alat yang dituju, Automatic Stacking Crane, masih berupa risiko umum yang berhubungan dengan kecelakaan dan ketidakmampuan ASC untuk bekerja secara umum. Sementara, jika ada kegagalan dalam proses yang berhubungan dengan ASC, Terminal Teluk Lamong merekam kegagalan dalam bentuk data digital, namun tidak memiliki mitigasi lebih lanjut.

Namun, data-data historis mengenai kesalahan yang terjadi serta penilaian yang telah dilakukan hanya digunakan sebagai syarat kelengkapan laporan tahunan. Diketahui pula bahwa dalam sistem manajemen risiko yang digunakan saat ini tidak disusun strategi penanganan risiko yang teridentifikasi.

Adapun potensi risiko yang dapat terjadi pada aktivitas proses bisnis Terminal Teluk Lamong berdasarkan informasi responden yakni sebagai berikut.

1. Ketidaksesuaian order
2. Ketidaksesuaian barang
3. Kontainer tidak standar
4. Kendaraan belum siap
5. Truk terlambat
6. Filter sistem tidak bekerja
7. Filter sistem tidak sesuai dengan kondisi nyata (ukuran kontainer, isi kontainer, tujuan)
8. Sistem error

9. Salah input penjadwalan
10. Peralatan rusak
11. Pekerja tidak mengurus barang dengn hati-hati
12. Sensor error
13. Crane rubuh
14. Wire sling putus
15. Salah informasi
16. Salah jadwal
17. Tabrakan antar truk
18. Cedera hingga kematian
19. Kendaraan rusak
20. Properti perusahaan rusak
21. Kegiatan bongkar muat terhenti
22. Truk menabrak pagar beton atau pohon
23. Polusi udara
24. ISPA
25. Heat stroke
26. Iritiasi mata
27. Dehidrasi
28. Trailer terangkat
29. Kunci kontainer rusak
30. Properti perusahaan rusak
31. Truk menabrak booth
32. Crane rubuh
33. Wire sling putus
34. Kontainer rubuh
35. Kesalahan penumpukan kontainer
36. Tumpukan kontainer miring
37. Kontainer stuck
38. ASC spreader stuck ke kontainer
39. Isi kontainer tumpah
40. Salah tujuan
41. Salah informasi tentang tujuan kontainer
42. Salah input tempat kontainer
43. Kontaminasi limbah ke tanah
44. Petugas mekanik keracunan
45. Petugas mekanik tersetrum
46. Tabung udara meledak
47. Petugas mekanik terpeleset
48. Petugas mekanik tersiram oli
49. Petugas mekanik jatuh
50. Petugas mekanik tertimpa
51. Petugas mekanik terjepit

52. Petugas mekanik tertabrak kendaraan
53. Petugas mekanik terpapar bahan berbahaya
54. Petugas mekanik tersetrum

KUESIONER TAHAP II

Petunjuk Pengisian : Bapak/Ibu dimohon untuk menilai masing-masing potensi risiko dengan memberikan tanda centang (✓) pada nilai yang dikehendaki.

Keterangan :

1– Sangat tidak setuju
2 – Sangat setuju
3 – Ragu-ragu
4 – Setuju
5 – Sangat setuju

Kode Aktvts	Deskripsi Aktivitas	Kode Potensi Risiko	Potensi Risiko	1	2	3	4	5
A1	Order masuk dari pelanggan	R1	Ketidaksesuaian order					
		R2	Ketidaksesuaian barang					
		R3	Kontainer tidak standar					
		R4	Kendaraan belum siap					
A2	Penjadwalan oleh bagian perencanaan	R5	Truk terlambat					
		R6	Filter sistem tidak bekerja					
		R7	Filter sistem tidak sesuai dengan kondisi nyata (ukuran kontainer, isi kontainer, tujuan)					
		R8	Sistem error					
A3	Input penjadwalan ke dalam sistem	R9	Salah input penjadwalan					
B1	Proses bongkar dari kapal	R10	Peralatan rusak					
		R11	Pekerja tidak mengurus barang dengn hati-hati					
B2	Perpindahan kontainer dari dermaga ke WSTA	R3	Kontainer tidak standar					
B3	Lift on/off dengan ASC	R3	Kontainer tidak standar					
		R8	Sistem error					

Kode Aktvts	Deskripsi Aktivitas	Kode Potensi Risiko	Potensi Risiko	1	2	3	4	5
		R12	Sensor error					
		R13	Crane rubuh					
		R14	Wire sling putus					
C1	Permintaan kontainer, kapal sandar	R15	Salah informasi					
		R16	Salah jadwal					
C2	Perpindahakan kontainer dari lapangan penumpukan ke WSTA	R3	Kontainer tidak standar					
C3	Perpindahan kontainer dari WSTA ke dermaga	R17	Tabrakan antar truk					
D1	Truk parkir di LSTA	R18	Cedera hingga kematian					
		R19	Kendaraan rusak					
		R20	Properti perusahaan rusak					
		R21	Kegiatan bongkar muat terhenti					
		R17	Tabrakan antar truk					
		R22	Truk menabrak pagar beton atau pohon					
		R23	Polusi udara					
		R24	ISPA					
		R25	Heat stroke					
		R26	Iritiasi mata					
		R27	Dehidrasi					
D2	Pembukaan twistlock chasis oleh supir	R28	Trailer terangkat					
		R29	Kunci kontainer rusak					
D3	Konfirmasi booth	R8	Sistem error					

Kode Aktvts	Deskripsi Aktivitas	Kode Potensi Risiko	Potensi Risiko	1	2	3	4	5
	dengan gesek ID supir	R30	Properti perusahaan rusak					
D4	Komunikasi antara supir truk dengna operator ASC	R31	Truk menabrak booth					
		R19	Kendaraan rusak					
		R18	Cedera hingga kematian					
		R20	Properti perusahaan rusak					
		R21	Kegiatan bongkar muat terhenti					
D5	Lift on/off dengan ASC	R3	Kontainer tidak standar					
		R8	Sistem error					
		R12	Sensor error					
		R32	Crane rubuh					
		R33	Wire sling putus					
D6	Menumpuk kontainer di lapangan penumpukan	R34	Kontainer rubuh					
		R35	Kesalahan penumpukan kontainer					
		R36	Tumpukan kontainer miring					
		R37	Kontainer stuck					
		R38	ASC spreader stuck ke kontainer					
		R39	Isi kontainer tumpah					
D7	Menumpuk kontainer di luar lapangan penumpukan	R40	Salah tujuan					
D8	Konfirmasi lokasi kontainer	R41	Salah informasi tentang tujuan kontainer					

Kode Aktvts	Deskripsi Aktivitas	Kode Potensi Risiko	Potensi Risiko	1	2	3	4	5
	oleh operator ASC	R42	Salah input tempat kontainer					
E1	Ganti oli	R18	Cedera hingga kematian					
		R43	Kontaminasi limbah ke tanah					
		R44	Petugas mekanik keracunan					
		R45	Petugas mekanik tersetrum					
		R46	Tabung udara meledak					
		R47	Petugas mekanik terpeleset					
		R48	Petugas mekanik tersiram oli					
E2	Ganti hose line	R49	Petugas mekanik jatuh					
		R18	Cedera hingga kematian					
		R43	Kontaminasi limbah ke tanah					
		R44	Petugas mekanik keracunan					
		R47	Petugas mekanik terpeleset					
		R50	Petugas mekanik tertimpa					
E3	Ganti motor listrik	R49	Petugas mekanik jatuh					
		R18	Cedera hingga kematian					
		R43	Kontaminasi limbah ke tanah					
		R44	Petugas mekanik keracunan					
		R47	Petugas mekanik terpeleset					
		R50	Petugas mekanik tertimpa					
		R51	Petugas mekanik terjepit					
E4	Ganti instalasi listrik	R49	Petugas mekanik jatuh					
		R18	Cedera hingga kematian					
		R43	Kontaminasi limbah ke tanah					
		R44	Petugas mekanik keracunan					
		R47	Petugas mekanik terpeleset					

Kode Aktvts	Deskripsi Aktivitas	Kode Potensi Risiko	Potensi Risiko	1	2	3	4	5
		R50	Petugas mekanik tertimpa					
		R51	Petugas mekanik terjepit					
		R30	Peralatan rusak					
		R52	Petugas mekanik tertabrak kendaraan					
		R53	Petugas mekanik terpapar bahan berbahaya					
E5	Inspeksi ASC	R49	Petugas mekanik jatuh					
		R54	Petugas mekanik tersetrum					
		R47	Petugas mekanik terpeleset					
		R51	Petugas mekanik terjepit					
		R50	Petugas mekanik tertimpa					

Catatan tambahan mengenai potensi risiko yang belum disebutkan

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Terima kasih atas kesediaan Bapak/Ibu untuk melengkapi kuisioner penelitian ini.

Surabaya, …… Mei 2018

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ATTACHMENT C

KUESIONER FMECA

PENILAIAN RISIKO MANAJEMEN RISIKO UNTUK PERALATAN AUTOMATIC STACKING CRANE DI TERMINAL TELUK LAMONG DENGAN PENDEKATAN METODE FMECA

Kuesioner ini bertujuan untuk melakukan penilaian risiko pada seluruh aktivitas yang berhubungan dengan Automatic Stacking Crane Terminal Teluk Lamong. Hasil kuesioner akan diolah lebih lanjut dan digunakan untuk kepentingan akademik (penelitian tugas akhir).

Perlu diketahui bahwa penelitian ini hanya dilakukan untuk PROSES OPERASI dari alat AUTOMATIC STACKING CRANE. Kuesioner berikut terdiri dari dua bagian, mohon Bapak/Ibu mengikuti petunjuk pada tiap-tiap bagian.

PENILAIAN RISIKO

Kriteria dalam menilai risiko mengacu kepada *The Basics of FMEA* oleh McDermott. Kriteris tersebut adalah sebagai berikut.

1. Dampak dari Kejadian Risiko *(Severity)*

   Berikut ini skala penilaian besaran dampak akibat terjadinya risiko *(severity).*

Rank	*Effect of Severity*	*Customer Effect*
1	*No Effect*	Kegagalan tidak memberikan efek
2	*Annoyance*	Kegagalan memberikan efek yang berpengaruh pada minoritas *customer* (<25%)
3		Kegagalan memberikan efek yang berpengaruh pada separuh *customer* (50%)
4		Kegagalan memberikan efek yang berpengaruh pada mayoritas *customer* (>75%)
5	*Loss or Degradation of Secondary Function*	Kegagalan memberikan efek terhadap penurunan fungsi sampingan sistem
6		Kegagalan memberikan efek terhadap hilangnya fungsi sampingan sistem
7	*Loss or Degradation of Primary Function*	Kegagalan memberikan efek terhadap penurunan fungsi utama sistem
8		Kegagalan memberikan efek terhadap hilangnya fungsi utama sistem

Rank	*Effect of Severity*	*Customer Effect*
9	*Failure to Meet Safety and/or Regulatory Requirements*	Kegagalan membahayakan sistem dengan adanya peringatan terlebih dahulu
10		Kegagalan membahayakan sistem tanpa adanya peringatan terlebih dahulu

2. Frekuensi Terjadinya Penyebab Risiko *(Occurence)*

Berikut ini skala penilaian frekuensi terjadinya penyebab risiko *(occurence).*

Rank	*Likelihood of Failure*	*Possible Failure Rate*
1	*Very Low*	Kegagalan dapat dieliminasi dengan langkah preventif
2	*Low*	≤ 0,001 per 1.000 1 dari 1.000.000
3		0,01 per 1.000 1 dari 100.000
4	*Moderate Moderate*	0,1 per 1.000 1 dari 10.000
5		0,5 per 1.000 1 dari 2.000
6		2 per 1.000 1 dari 500
7	*High*	10 per 1.000 1 dari 100
8		20 per 1.000 1 dari 50
9		50 per 1.000 1 dari 20
10	*Very High*	≥100 per 1.000 1 dari 10

3. Peluang Risiko Dapat Terdeteksi (*Detection*)

Berikut ini skala penilaian peluang sebuah risiko dapat terdeteksi *(detection).*

Rank	*Likelihood of Detection*	*Opportunity for Detection*
1	*Almost Certain*	Pengecekan selalu bisa mendeteksi kegagalan
2	*Very High*	Pengecekan hampir selalu bisa mendeteksi kegagalan

Rank	*Likelihood of Detection*	*Opportunity for Detection*
3	*High*	Pengecekan bisa mendeteksi kegagalan
4	*Moderately High*	Pengecekan berpeluang sangat besar bisa mendeteksi kegagalan
5	*Moderate*	Pengecekan berpeluang besar bisa mendeteksi kegagalan
6	*Low*	Pengecekan kemungkinan bisa mendeteksi kegagalan
7	*Very Low*	Pengecekan berpeluang kecil bisa mendeteksi kegagalan
8	*Remote*	Pengecekan berpeluang sangat kecil bisa mendeteksi kegagalan
9	*Very Remote*	Pengecekan gagal sehingga tidak mampu mendeteksi kegagalan

Petunjuk Pengisian : Bapak/Ibu dimohon untuk menilai daftar risiko dengan skala 1-10 sesuai dengan kriteria penilaian yang telah dijelaskan.

Kode Aktvts	Deskripsi Aktivitas	Kode Potensi Risiko	Potensi Risiko	S	O	D
A1	Order masuk dari pelanggan	R2	Ketidaksesuaian barang			
		R3	Kontainer tidak standar			
		R4	Kendaraan belum siap			
A2	Penjadwalan oleh bagian perencanaan	R5	Truk terlambat			
		R6	Filter sistem tidak bekerja			
		R7	Filter sistem tidak sesuai dengan kondisi nyata (ukuran kontainer, isi kontainer, tujuan)			
		R8	Sistem error			
A3	Input penjadwalan ke dalam sistem	R9	Salah input penjadwalan			
B1	Proses bongkar dari	R10	Peralatan rusak			

Kode Aktvts	Deskripsi Aktivitas	Kode Potensi Risiko	Potensi Risiko	S	O	D
	kapal	R11	Pekerja tidak mengurus barang dengn hati-hati			
B2	Perpindahan kontainer dari dermaga ke WSTA	R3	Kontainer tidak standar			
B3	Lift on/off dengan ASC	R3	Kontainer tidak standar			
		R8	Sistem error			
		R12	Sensor error			
		R13	Crane rubuh			
		R14	Wire sling putus			
C1	Permintaan kontainer, kapal sandar	R15	Salah informasi			
		R16	Salah jadwal			
C2	Perpindahakan kontainer dari lapangan penumpukan ke WSTA	R3	Kontainer tidak standar			
C3	Perpindahan kontainer dari WSTA ke dermaga	R17	Tabrakan antar truk			
D1	Truk parkir di LSTA	R18	Cedera hingga kematian			
		R19	Kendaraan rusak			
		R20	Properti perusahaan rusak			
		R21	Kegiatan bongkar muat terhenti			
		R17	Tabrakan antar truk			

Kode Aktvts	Deskripsi Aktivitas	Kode Potensi Risiko	Potensi Risiko	S	O	D
		R22	Truk menabrak pagar beton atau pohon			
		R23	Polusi udara			
		R24	ISPA			
		R25	Heat stroke			
		R26	Iritiasi mata			
		R27	Dehidrasi			
D2	Pembukaan twistlock chasis oleh supir	R28	Trailer terangkat			
D3	Konfirmasi booth dengan gesek ID supir	R8	Sistem error			
		R30	Properti perusahaan rusak			
D4	Komunikasi antara supir truk dengna operator ASC	R31	Truk menabrak booth			
		R19	Kendaraan rusak			
		R18	Cedera hingga kematian			
		R20	Properti perusahaan rusak			
		R21	Kegiatan bongkar muat terhenti			
D5	Lift on/off dengan ASC	R3	Kontainer tidak standar			
		R8	Sistem error			

Kode Aktvts	Deskripsi Aktivitas	Kode Potensi Risiko	Potensi Risiko	S	O	D
		R12	Sensor error			
		R32	Crane rubuh			
		R33	Wire sling putus			
D6	Menumpuk kontainer di lapangan penumpukan	R34	Kontainer rubuh			
		R35	Kesalahan penumpukan kontainer			
		R36	Tumpukan kontainer miring			
		R37	Kontainer stuck			
		R38	ASC spreader stuck ke kontainer			
		R39	Isi kontainer tumpah			
		R55	ASC di water side menabrak ASC di land side			
		R56	ASC yang bergerak menabrak tumpukan kontainer			
D7	Menumpuk kontainer di luar lapangan penumpukan	R40	Salah tujuan			
D8	Konfirmasi lokasi kontainer oleh operator ASC	R41	Salah informasi tentang tujuan kontainer			
		R42	Salah input tempat kontainer			
E1	Ganti oli	R18	Cedera hingga kematian			
		R43	Kontaminasi limbah ke tanah			

Kode Aktvts	Deskripsi Aktivitas	Kode Potensi Risiko	Potensi Risiko	S	O	D
		R44	Petugas mekanik keracunan			
		R45	Petugas mekanik tersetrum			
		R46	Tabung udara meledak			
		R47	Petugas mekanik terpeleset			
		R48	Petugas mekanik tersiram oli			
E2	Ganti hose line	R49	Petugas mekanik jatuh			
		R18	Cedera hingga kematian			
		R43	Kontaminasi limbah ke tanah			
		R44	Petugas mekanik keracunan			
		R47	Petugas mekanik terpeleset			
		R50	Petugas mekanik tertimpa			
E3	Ganti motor listrik	R49	Petugas mekanik jatuh			
		R18	Cedera hingga kematian			
		R43	Kontaminasi limbah ke tanah			
		R44	Petugas mekanik keracunan			
		R47	Petugas mekanik terpeleset			
		R50	Petugas mekanik tertimpa			

Kode Aktvts	Deskripsi Aktivitas	Kode Potensi Risiko	Potensi Risiko	S	O	D
		R51	Petugas mekanik terjepit			
E4	Ganti instalasi listrik	R49	Petugas mekanik jatuh			
		R18	Cedera hingga kematian			
		R43	Kontaminasi limbah ke tanah			
		R44	Petugas mekanik keracunan			
		R47	Petugas mekanik terpeleset			
		R50	Petugas mekanik tertimpa			
		R51	Petugas mekanik terjepit			
		R30	Peralatan rusak			
		R52	Petugas mekanik tertabrak kendaraan			
		R53	Petugas mekanik terpapar bahan berbahaya			
E5	Inspeksi ASC	R49	Petugas mekanik jatuh			
		R54	Petugas mekanik tersetrum			
		R47	Petugas mekanik terpeleset			
		R51	Petugas mekanik terjepit			
		R50	Petugas mekanik tertimpa			

ATTACHMENT D

KUESIONER DEMATEL

PENILAIAN KORELASI RISIKO MANAJEMEN UNTUK PERALATAN AUTOMATIC STACKING CRANE DI TERMINAL TELUK LAMONG DENGAN PENDEKATAN METODE DEMATEL

Kuesioner ini bertujuan untuk melakukan penilaian hubungan antar risiko risiko pada seluruh aktivitas yang berhubungan dengan peralatan Automatic Stacking Crane di Terminal Teluk Lamong. Hasil kuesioner akan diolah lebih lanjut dan digunakan untuk kepentingan akademik (penelitian tugas akhir).

PENILAIAN HUBUNGAN RISIKO

Kriteria dalam menentukan hubungan antar risiko mengacu pada metode DEMATEL adalah sebagai berikut.

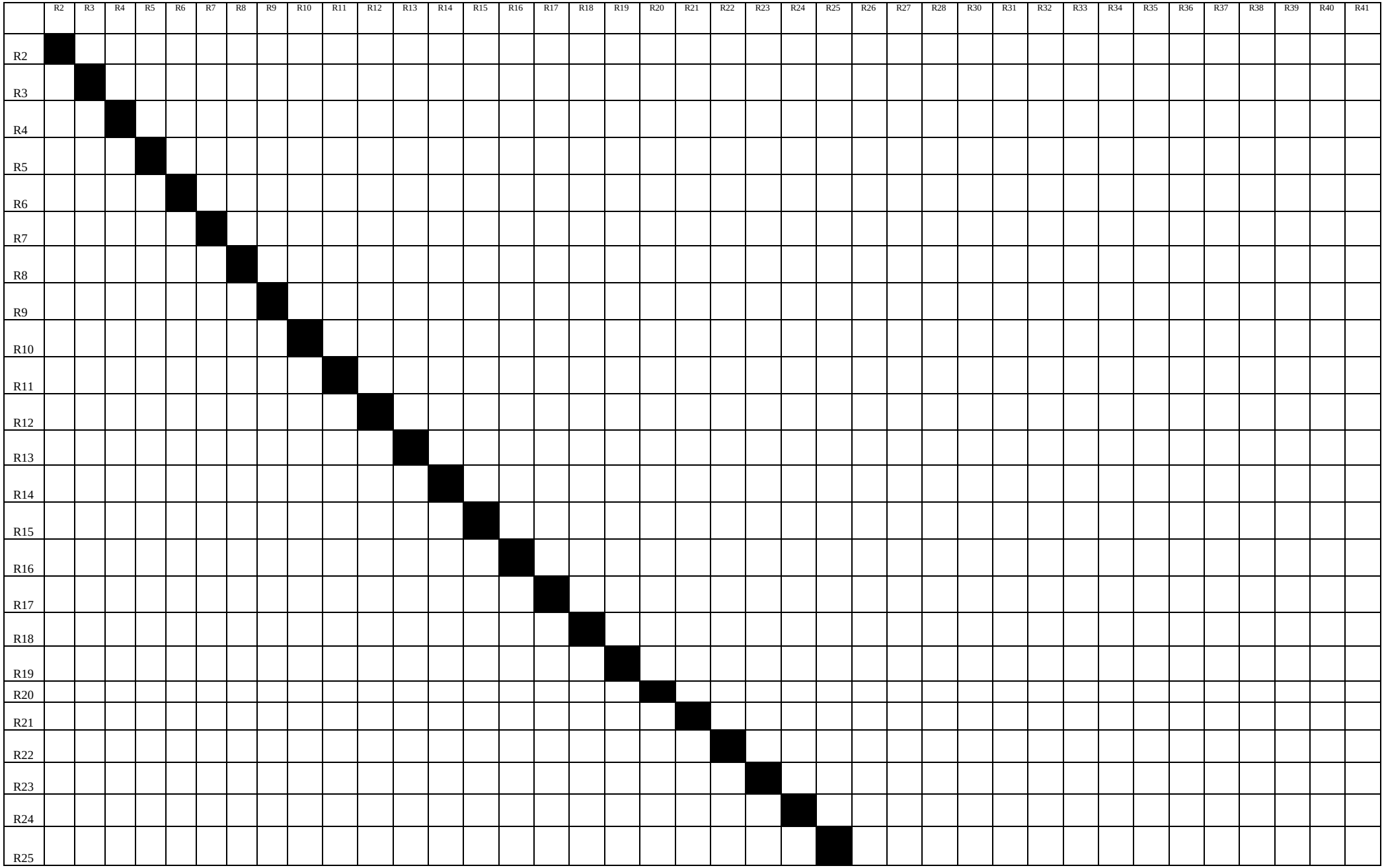
0 – Tidak ada pengaruh
1 – Pengaruh rendah
2 – Pengaruh sedang
3 – Pengaruh tinggi
4 – Pengaruh sangat tinggi

Petunjuk Pengisian : Bapak/Ibu dimohon untuk mengisi nilai pengaruh risiko yang tertera pada baris terhadap risiko yang tertera pada kolom sesuai dengan kriteria penilaian yang telah dijelaskan.

Kode Potensi Risiko	Potensi Risiko
R2	Ketidaksesuaian barang
R3	Kontainer tidak standar
R4	Kendaraan belum siap
R5	Truk terlambat
R6	Filter sistem tidak bekerja
R7	Filter sistem tidak sesuai dengan kondisi nyata (ukuran kontainer, isi kontainer, tujuan)
R8	Sistem error
R9	Salah input penjadwalan
R10	Peralatan rusak
R11	Pekerja tidak mengurus barang dengn hati-hati
R12	Sensor error
R13	Crane rubuh
R14	Wire sling putus
R15	Salah informasi
R16	Salah jadwal
R17	Tabrakan antar truk

Kode Potensi Risiko	Potensi Risiko
R18	Cedera hingga kematian
R19	Kendaraan rusak
R20	Properti perusahaan rusak
R21	Kegiatan bongkar muat terhenti
R22	Truk menabrak pagar beton atau pohon
R23	Polusi udara
R24	ISPA
R25	Heat stroke
R26	Iritiasi mata
R27	Dehidrasi
R28	Trailer terangkat
R30	Properti perusahaan rusak
R31	Truk menabrak booth
R32	Crane rubuh
R33	Wire sling putus
R34	Kontainer rubuh
R35	Kesalahan penumpukan kontainer
R36	Tumpukan kontainer miring
R37	Kontainer stuck
R38	ASC spreader stuck ke kontainer
R39	Isi kontainer tumpah
R40	Salah tujuan
R41	Salah informasi tentang tujuan kontainer
R42	Salah input tempat kontainer
R43	Kontaminasi limbah ke tanah
R44	Petugas mekanik keracunan
R45	Petugas mekanik tersetrum
R46	Tabung udara meledak
R47	Petugas mekanik terpeleset
R48	Petugas mekanik tersiram oli
R49	Petugas mekanik jatuh
R50	Petugas mekanik tertimpa
R51	Petugas mekanik terjepit
R52	Petugas mekanik tertabrak kendaraan
R53	Petugas mekanik terpapar bahan berbahaya
R54	Petugas mekanik tersetrum
R55	ASC di water side menabrak ASC di land side
R56	ASC yang bergerak menabrak tumpukan kontainer

Kuesioner Hubungan Antar Risiko dengan Menggunakan Metode DEMATEL (


R2 R3 R4 R5 R6 R7 R8 R9 R10 R11 R12 R13 R14 R15 R16 R17 R18 R19 R20 R21 R22 R23 R24 R25
R2 R3 R4 R5 R6 R7 R8 R9 R10 R11 R12 R13 R14 R15 R16 R17 R18 R19 R20 R21 R22 R23 R24 R25 R26 R27 R28 R30 R31 R32 R33 R34 R35 R36 R37 R38 R39 R40 R41

	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21	R22	R23	R24	R25	R26	R27	R28	R30	R31	R32	R33	R34	R35	R36	R37	R38	R39	R40	R41
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BIOGRAPHY

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