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Port of Klaipeda Risk Assessment Concerning Safety of Marine Operations

The Master of Science in Technology in Risk and Safety Management Thesis

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Abstract

This document reviews Klaipeda port, its origins and history. Cargo handling dynamics and characteristics are included with stakeholders which has influence on or is influenced by this seaport. All the information mentioned above supports risk assessment about safety of marine operations in this port. Goal of the analysis is identifying all the risks existent in the seaport while conducting marine operations overall and finding out which of the identified risks are the most acute. This is made using statistical data, failure mode and effect analysis, bow-tie method and brainstorming Also risk treatment plan is used for safety of marine operations in general.

Aftermath of the analysis shows three main risks identified, distinguished from others with highest risk priority numbers in the FMEA analysis. For each of them, bow-tie is used in order to provide more thorough research of these risks. Threats and consequences with relevant barriers are identified. Results of the research suggests that overall safety of operations in the port is ensured, but improvement is needed in internal shipping companies. More attention should be given to supervision, training and emergency preparedness in the operations where direct human intervention is inevitable.

Preface

The aim of this document is to give an overview about Klaipeda port, what operations are done in the port, types of cargoes handled, what stakeholders are involved. While linking all the aspects, conduct a risk assessment which includes identifying most common risk factors while executing marine operations. The document is written based on problem based learning (PBL) principle, used in Aalborg University. Risk assessment is made using risk treatment plan methodology, FMEA analysis and bow-tie method in Chapter 4.

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Acronyms

KSSPA – Klaipeda State Sea Port Authority

CIS – Commonwealth of Independent States organization

ESPO – European Sea Ports Organization

IMO – International Maritime Organization

LMSA – Lithuanian Maritime Safety Administration

LSCA – Lithuanian Stevedoring Companies Association

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1. Introduction

Maritime history takes us back thousands of years. The first evidence of maritime trade between civilizations dates back at least two millennia, which verifies that shipping was then and is now important part of human civilization. In the very beginning the so called “ships” of that day were simple dugout canoes or rafts and only in the later centuries it developed a form close to today’s ship. With the increase of human population, more need for fishing, international trade, exploration and colonization appeared, thus more ships were built. This lead to development of harbors and human population gathering on coastlines.

Today maritime transport is essential to world’s economy, since over 90% of the world’s trade is carried by sea and it is, by far, the most cost effective way to move mass goods and raw materials around the world. Most part of cargo handling is done at the seaports, therefore risk and safety management in these areas is substantial in order to load and unload ships smoothly, as well as navigate them properly within port waters. With respect to that, in this document risk assessment analysis concerning safety of marine operations is going to be conducted about one of the Baltic states largest port Klaipeda.

The analysis will be conducted based on the information provided from Klaipeda State Sea Port Authority(KSSPA) and only will cover overall risk and safety management plans as being the landowner of the port territory also including port waters. Largest port stevedoring companies will also be involved briefly in the analysis, mainly because specific methodology may vary in different companies due to diverse types of cargo handled and these kinds of analyses should be conducted one at a time since they have to be more thorough. Safety of marine operations in this document goes by meaning: ship traffic, ship berthing, ship inspection before entering the port, oil spills control, cargo handling.

2. Overview and history

Klaipeda city port history begun in 1252 July 29th, when Curonian bishop and first and only king of Lithuania Mindaugas agreed to build a castle in Klaipeda. Soon after, the city became constant stop for Lubeck and Bremen merchant ships. Klaipeda port is situated on the east cost of the Baltic Sea, followed by other ports like Kaliningrad, Gdynia, Gdansk in the south and Ventspils, Riga and Tallinn in the north as it is shown in the Figure 1.

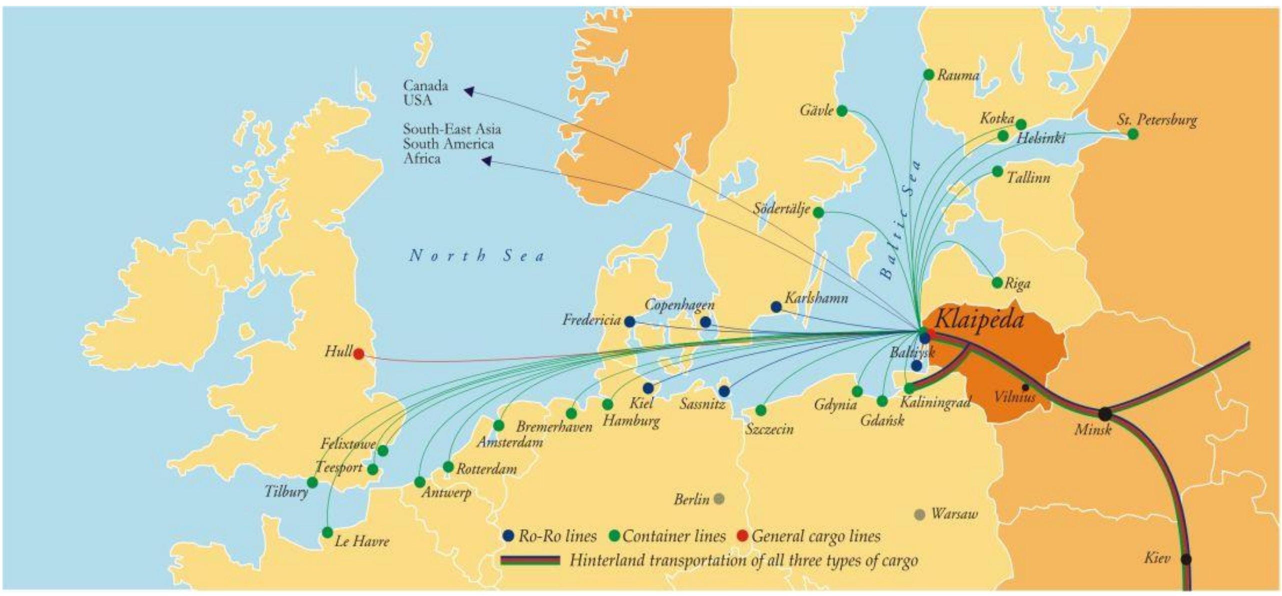


Figure 1. Klaipeda port geographical location and shipment routes.[1]

Throughout port lifetime it constantly developed reaching its peak at the time in 1743, when timber sales office was founded in Klaipeda. Then it was the most known timber port in Baltic Sea. In 1797 written documents, it is stated that in Klaipeda port 300 ships can be berthed, while handling timber cargo. Further development continued, but because of first World War and changing political dependency of Lithuania and Klaipeda district on different nations (Germany, Soviet Union) no nationalized authority was established until 1923. Prosperity of the harbor began after that until the beginning of World War II in 1939. In this period of 16 years, new quays have been built as well as establishment of new maritime and shipping organizations. At that period Lithuanian government invested 42 mln. Litas (equivalent 13 mln. Euros) into the port infrastructure. After the second Word War ended, cargo handling operations were still conducted but the port itself was not growing rapidly. Only in 1991 after Lithuania retrieved its independency from Soviet Union, Klaipeda State Port Authority (KSSPA) was established and constant, rapid growth begun. From the start of activity until 2013 12 31, KSSPA and various stevedoring companies invested in port 1.52 billion euros. Today it is a major part of Lithuanian economy with creating around 6.24 % of GDP.[2]

2.1. Port characteristics

As mentioned previously much effort and investments has been made to reach the level of importance as an intermodal and transit center, not only for Lithuania but for the countries of the Commonwealth of Independent States organization (CIS) for which goods transits through Klaipeda port. To give a better understanding of size of the port main characteristics can be seen in Table 1.

Table 1. Klaipeda port characteristics and warehousing infrastructure. [3]

CHARACTERISTICS	
Port teritorry	538,7 ha
Port waters	877,2 ha
Overall port berths length	27,6 km
Overall port railroads length	90 km
Northern breakwater length	733 m
Southern breakwater length	1374 m
Fairway depth	14,5 m
WAREHOUSING INFRASTRUCTURE	
Covered warehouse space for general cargo	99 380 m^2
Bulk cargo handling capacity	933 700 t
Refrigerated cargo handling capacity	66 000 t
Open site warehousing space	1 045 879 m^2
Reservoirs volume for liquid cargo	749 000 m^3

Besides the given characteristics above, today in Klaipeda port there are 368 companies with registered status as “Port Company” which provides ship agency, stevedoring, inspection, supply, cargo handling and warehousing, repairs as well as the other services to maintain stable work of the seaport. Overall number of enterprises connected to the seaport is more than 800 and with this amount of companies it has a big significance for inhabitants of Klaipeda, because many jobs are created.[4]

In the Figure 1, Klaipeda port plan can be seen, where markings in orange refers to port territory. As you can see, the port is laid out lengthwise on the coast of the city, where across the port waters there is Curonian spit, which is guarded teritorry as national park, as well as UNESCO World Herritage Site.

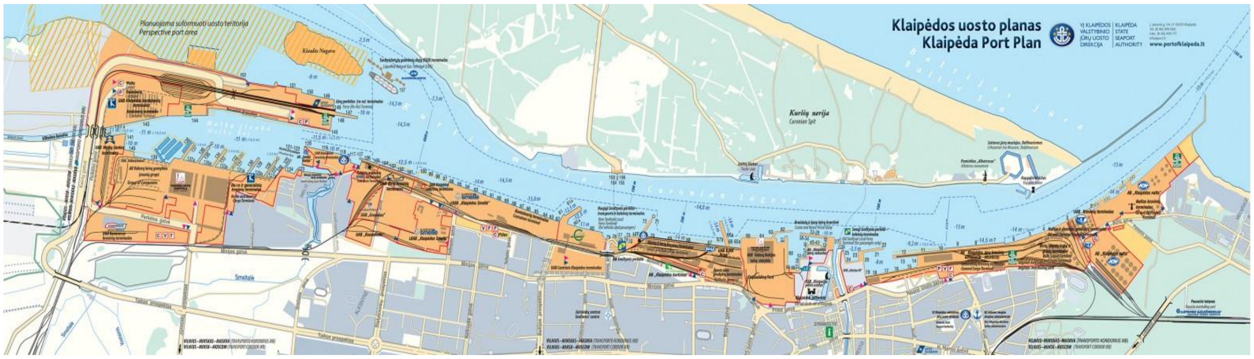


Figure 2. Klaipeda Port Plan [5]

This layout is convenient for coming ships, since the berthing operations are easier, and ship traffic can be regulated simpler. The only downside is that basically at every point where port territory boundaries ends, city's territory begins with residential housing. It is a problem both for the port authority and residents. Whereas port authority cannot expand the territory of the port, and for residents - constant noise, heavy truck and train traffic, air pollution from handled cargo. Nevertheless, Klaipeda State Port Authority is constantly collaborating with Klaipeda municipality to implement new truck traffic routes and also raise the bar in the legislation for the port companies, which handles dusty cargo.

2.2. Cargo handling dynamics

As mentioned in the previous subchapters Klaipeda port cargo handling was increasing steadily since the retrieval of Lithuanian independency in 1991 and establishment of KSPA. This can be seen in the following figures taken from Klaipeda port official website.

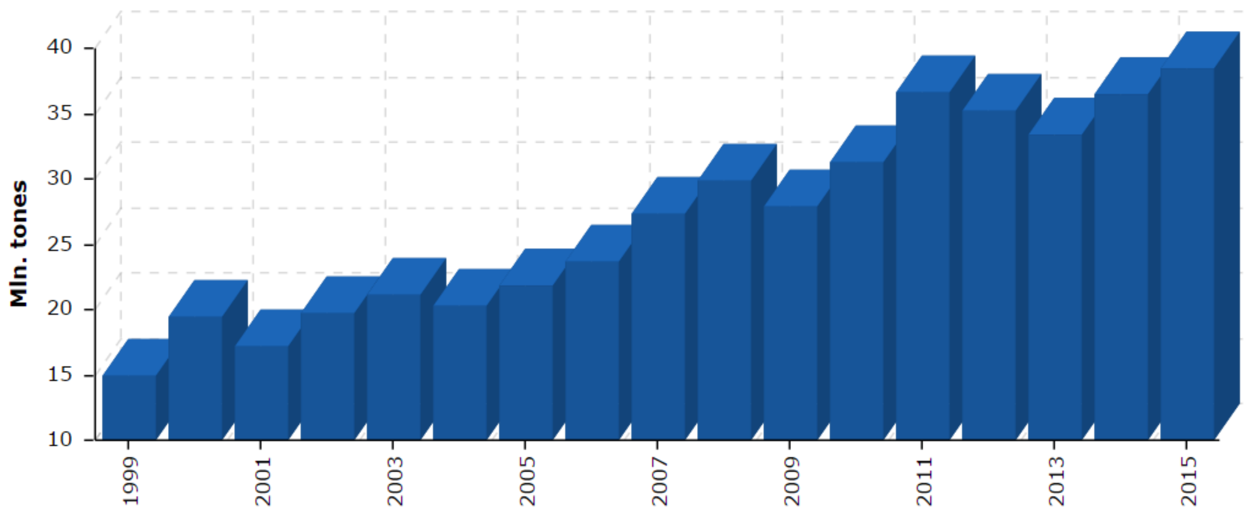


Figure 3. Annual cargo turnover of Klaipeda port (mln. tones)[6]

In the year 1999 the turnover was 14.97 mln. tones, whereas in 2015 it reached 38.51 mln. tones. This means 257% increase over 16 years and suggests that investments made through this period of time for the infrastructure were correct and lead to new customer wave choosing Klaipeda port for their goods transit. In figure 3 the decrease of the turnover can be seen in 2009 and 2013. The one in 2009 was the impact of global economic crisis, whereas the one in 2012 and 2013 was because of bulk, general cargo and oil products handling decrease.

Klaipeda seaport specializes in many different cargos, and could not be stated as one type cargo seaport as for example like Hamburg, which could be named as container port or Tallinn as oil products port since there one type of cargo dominates the turnover and takes more than 50 % of the share. In the following pie chart percentages of different cargos handled in Klaipeda port in 2015 can be seen.

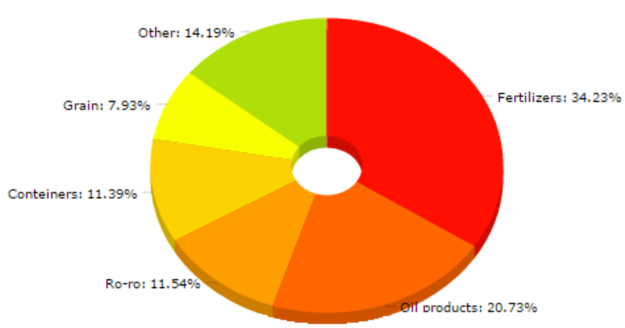


Figure 4. Structure of handled cargo in Klaipeda port in 2015. [6]

Figure 4 shows that 34% of cargo handled in Klaipeda port is fertilizers, which transits to CIS countries. Almost twenty one percent is taken by oil products and with this it is worth mentioning that most of it is handled at Būtingė Terminal, which was built specially for oil products handling, is situated 45 kilometers up north from Klaipeda, nearby Lithuanian – Latvian border. Nevertheless its location, Būtingė Terminal is still assigned as part of Klaipeda seaport.

Third cargo type refered as „Other“ with 14.19% handled in 2015, includes wood, metal scrap, sugar raw material, refrigerated cargo, iron alloys, building materials etc. Fifth largest group of cargo as shown in Figure 3 is Ro-ro with 11.54%. Ro-ro vessels are constructed so they would be able to take up wheeled cargo, like trucks and cars. The relatively high part of total turnover in 2015 of ro-ro vessels is because of two ferry lines to Kiel and Karlshamn which are operated by Danish shipping operator "DFDS Seaways".

Information provided in previous chapters gives an introduction and brief understanding about Klaipeda port characteristics, size, what types of cargo are handled and shows that annual cargo handling turnover is constantly rising. In light of this the amount of ships coming to the port will also increase. Subsequently, more attention is dedicated to smooth execution of marine operations within port waters.

In the next part of the document problem formulation and delimitation will be conducted. Which will raise question of the main problem followed by sub-questions in order to answer it more explicitly. These questions will be the pillars of the document on which following chapters will be based.

3. Problem Formulation

In this chapter problem formulation is going to be conducted based on PBL model in Aalborg University. To do this the main problem is raised as well as parted sub-questions can be seen in bold in the following paragraph.

Which of the identified risks are the most acute for the safety of marine operations?

Sub questions:

Meaning of safety of marine operations (risk identification).

- *Marine operations in the port overview.*
- *Pointing out the most important ones.*
- *Whose actions influences safety?*
- *Who is influenced by safety?*
- *Why it is important for the port?*

How identified risks can be managed?

- *Application of FMEA to find the most acute risks.*
- *Application of bow-tie method.*

After all the questions are answered the projects main problem answer can be stated. Analysis will be based more on cargo handling operations, since it is the main reason why seaport was established and is being constantly improved. Subsequently, conclusion is written, showing what was derived from the research

3.1. Problem delimitation

For answering the sub-questions of the main problem few of the stakeholders or involved parties will be included. It is so, due to vast organizational involvement in Klaipeda port activities and lack of time. Risk and safety management plans will be introduced mainly from KSSPA, since this company directly interferes with all of the ships entering the port and is responsible for berthing infrastructure through-out all the port.

3.2.Outline

Next part of this document will include 2 chapter where the main problem will be answered. Chapter 4 consists of four subchapters, where each subchapter is related to sub-questions of the main problem. Third subchapter of chapter 4, will be conducted as risk treatment plan for the problem in question and fourth subchapter is for FMEA analysis and bow-tie method. Concluding chapter gives final statements after the analysis was made.

4. Analysis of the problem and methodology

Risk management is the identification, assessment, and prioritization of risks (defined in ISO 31000 as the effect of uncertainty on objectives) followed by coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate event or to maximize the realization of opportunities.[7] According to ISO, risk management process is risk assessment followed by risk identification, risk analysis and risk treatment. Throughout these 4 phases, monitoring and review, as well as communication and consultation is constant.

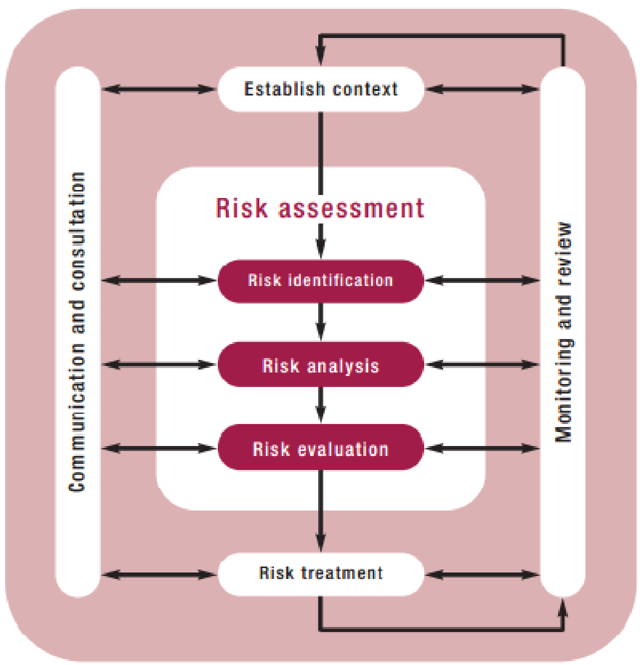


Figure 5. Risk management process according to ISO 31000

While interpreting this model three main parts of it can be referred as particular questions. For example, first part risk identification can be referred as questions like who/what/when/where/how. For the risk analysis part questions like why/how often/how much/how critical can be raised. As for the risk evaluation questions like what is acceptable or unacceptable/solution options/ priorities are suggested. Based on this method problem formulation was composed.

4.1.Identification of the stakeholders

As mentioned in chapter 3 “Problem formulation”, first two sub-questions of the main problem are to identify whose actions are influencing safety of marine operations as well as who is influenced by it. Since KSSPA is in the middle of this process as a party, which regulates the internal regulation of the port, all the interaction goes through it. Illustrated chart can be seen in Figure 5.

Figure 6. Klaipeda State Sea Port Authority stakeholders chart.

As it is shown in the stakeholder’s chart above, at least 6 important stakeholders are involved with the safety of marine operations as well as other regulations conducted by Klaipeda District Port Authority. This chart shows both, who is affected by the safety of marine operations and who affects it. Further on elaboration is given about each of the stakeholders.

4.1.1. Internal shipping companies

Internal shipping companies includes companies which are situated in Klaipėda port and operates there. As mentioned in chapter 2.1., today there are registered 368 “port companies”. All of these organizations can be stated as internal stakeholder, but mostly reference is to those which are the largest. These companies are members of Lithuanian Stevedoring Companies Association (LSCA) which was established in 1999. Association board members, holds constant meetings considering the relevant transport and transit issues. It involves the Lithuanian Parliament committees and submission of proposals to the Ministry of the Transit Committee. Since its inception, the association’s goal is to achieve the results from the overall work of implementing plans for the development, modernization, improvement and safety of Lithuanian maritime port system. These implementation plans are discussed with KSSPA, to approach the best decision.

It is worth mentioning four largest stevedoring companies:

- AB Klaipėdos Jūrų Krovinių Kompanija “KLASCO” which specializes in bulk, liquid cargo and fertilizers, total handling capacity is 18 mln. tones per year.[8]
- AB “Klaipėdos Nafta” which specializes in oil products and has total handling capacity of 8 mln. tones per year.[9]
- LKAB “Smeltė” which specializes in containers handling, and has a total capacity of 600.000 TEU per year. It was established in 2006 and is one the fastest growing companies.[10]
- KJKK “Bega” which specializes in bulk, liquid cargo and fertilizers, total handling capacity 10 mln. tones per year.[11]

These four companies as well as the smaller ones, specializes in different cargo handling therefore specific risk and safety management is question of the company’s inside politics. As for generalization, these companies can discuss common issues about ship traffic, lesser noise and air pollution for the inhabitants nearby port territory, regulations for ship berthing which can be presented to KSSPA. Since interaction goes both ways, KSSPA presents different issues to individual stevedoring companies as well as to LSCA. This suggests that internal shipping companies affects and is affected by safety of marine operations.

4.1.2. External shipping companies

External shipping companies includes operators who decided to ship their goods through Klaipėda port. This means that it is expected of KSSPA and internal shipping companies to guarantee that goods will be handled safely, ships will be supplied with necessary supplies (fresh water, fuel, food), in other words that the port would be appealing. As for safety of marine operations, the port itself has to meet the criteria specified in regulations by IMO and ESPO. For example, risk free zone of ship hijacking and piracy.

Important stakeholders of external shipping companies are cruise shipping operators. In 2016 season 51 cruise ships berthed in Klaipėda port.[12] For the port to be attractive for tourists, thus more cruise ships would come, it is a matter of municipality, for offering cultural, sightseeing, cuisine, music events and various other activities. But having in mind safety, again it is responsibility of KSSPA and internal company which serves the ship as well as the ship operator for the ship to be qualified to entering the port. This stakeholder would be more the one who affects the safety of marine operations, since KSSPA is always contributing to make the port more attractive.

4.1.3. ESPO and IMO

These two stakeholders act almost within the same field, the only difference is that IMO is international and takes whole maritime field, where ESPO is specially for Europe and concentrates on the ports. Both organizations have similar goals, but looking from hierarchy point of view IMO is higher, since worlds shipping industry is working under conventions and regulations created by IMO f.e. International Convention for Safety of Life at Sea (SOLAS).

As a specialized agency of the United Nations, IMO is the global standard-setting authority for the safety, security and environmental performance of international shipping.[13] From this reference it can be said that all the fields mentioned includes ships while they are at sea and cargo handling operations is a matter of the stevedoring company in the port. Nevertheless, given requirements by IMO in the SOLAS amendment - ISPS code, both ships and seaports has to meet them in order to fulfill regulations. Whereas ESPO key objectives are:

- Ensure that the economic importance of European ports is recognized in the European Union and its Member States and that the sector is heard on any measure likely to affect it;
- Promote free and fair competition in the port sector;
- Ensure that European ports play their full part in delivering economic efficiency;
- Promote the highest possible safety standards in European ports;

- Encourage ports to be proactive in protecting the environment.[14]

From the key objectives, it is clear the ESPO's goal is for the ports to be seen as important part of economy with their possible requirements to the European Union. Promotion of safety standards and environment protection is also mentioned but no specific actions are included, thus it suggests that safety requirements are executed based on IMO and individual port regulations. With that said, IMO and ESPO can be stated as the stakeholder which affects the safety of marine operations within Klaipėda port.

4.1.4. Government, Klaipėda municipality and civilians

The last three stakeholders also have an impact for KSSPA and safety of marine operations. Lithuanian government in 1994 established Klaipeda District Port Act. From then since port activities has been made based on this document. It is worth mentioning that KDAP is a governmental organization, therefore any changes to this document has to be discussed with government. Klaipeda District Port Act describes activities such as port management, port territory rent, commercial and economical activities, port funds, damage or loss compensation. In third chapter, article 31[1] "Port and port infrastructure and superstructure device (terminal) security assessment" it is stated that after the implemented assessment it is clear that port infrastructure and superstructure is up date and meets the requirements stated in ISPS code. This suggests that safety of marine operations is based on requirements raised by IMO. But again, these are general requirements and specific ones are raised individually, based on the stevedoring company.

Klaipėda municipality and civilians also has a vote in this field. Mainly this covers civilian complains about noise and air pollution. KSSPA is entitled to monitor stevedoring companies for any violations of the regulation and if so impose fines. Some of the cargo handled is hazardous and if incident happened, the consequences would affect the city vastly. Therefore, stevedoring companies are being assessed constantly. These three stakeholders have a big effect on safety of marine operations as well as are affected by it.

In the following subchapter third sub-question is going to be discussed in order to find out why safety of marine operations is an important problem to the case.

4.2.Importance of safety of marine operations

Importance of safety overall, nowadays is frequently discussed question, since being safe and providing safe environment at work is number one objective in any industry. This concept developed through time mainly because past accidents had huge consequences both economical and humane. In the shipping industry, many accidents happen every day in different parts of the world because of various reasons. This document specifically covers safety of marine operations within Klaipėda port territory and port waters. Thus, further on statistics of past accidents and consequences are given.

In Lithuania, all reported accidents involving human injuries are registered and investigated by State Labour Inspectorate of Republic of Lithuania. Since 2011 01 07 there has been 9 accidents registered in Klaipeda port stevedoring companies of which 5 resulted in death due to severe injuries. Further on some of the accidents are reviewed.

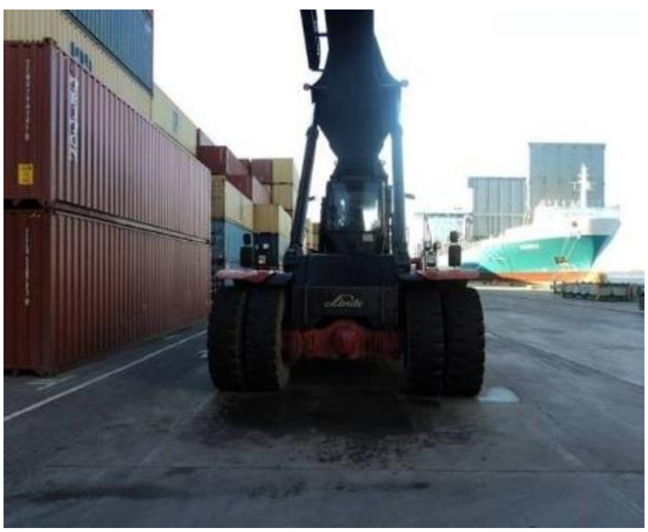


Figure 7 Telescopic container loader at LKAB "Smeltė"

In 2011 March 14th one of the workers of LKAB "Smeltė" container terminal was traumatized by a telescopic container loader which weight is around 20 tones (Figure 6). Docker – mechanizator, was the one conducting the operations by showing signs for the loader operators. At night shift around 23.30 employee walked into traffic zone of the loaders and was hit by one of them. When brought to the hospital the employee did not survive after severe injuries. The aftermath of this accident showed that docker – mechanizator was under the influence, since it was found 1.64 blood alcohol level. Conclusions given states, that mainly it was employee's fault, because he was walking on the traffic zone and also under the influence, but the employer was also responsible since with the alcohol amount given, he was not dismissed.[15]

Another interesting case is in 2011 March 10th at AB "KLASCO". A ship with raw sugar was unloaded to trucks, using grab crane and bunker-dispenser. After dropping the first grab into the bunker, sugar clogged and stop moving down into the truck. Docker-mechanizator took a scraper and in order to move clogged sugar faster jumped inside the bunker. At the same time sugar started to fall down taking the employee with it and drowning him. After the investigation, it was stated that it was employee's fault, since by the rules it is never allowed to jump inside the doser-dispenser, unless it is supervised by manager.[16]

Figure 8 Bunker-dispenser for dry bulk cargo handling at AB "KLASCO"

Third case took place in UAB "Konteinerių Terminalas" in 2014 March 12th. Group of dockers-mechanizators were unloading a ship with general oversized cargo (pipes, metal ware, wooden boxes etc.) By using mobile crane "Liebherr 320" packs of armature (length 9 meters, weight around 4 tones) were slinged by workers, but when the crane lifted the pack up it was seen, that the pack was slinged not through the mass centers, therefore it was asked by the crane operator to lower it down. Before lowering down the pack, some wooden planks were put under by the workers. When the pack was lowered, the wooden planks did not withstand the weight and broke, became unstable and pressed up one of the workers left leg. After the investigation, it was stated that dockers-mechanizators were instructed and qualified to do this kind of work, nevertheless the final conclusion was that unloading operations was executed incorrectly and there was bad organization of the work. In Figure 8 it can be seen the size of armature packs and wooden planks which broke.[17]

Figure 10. Wooden planks broken while unloading armature packs

Accidents mentioned above illustrates dangerous situations while loading and unloading ships. As you can see in some of the cases fatalities were inevitable. But besides these accidents in the port territory, there is a possibility of ship collisions into each other, berths or grounding which may result in serious economic damage to the ship and port companies**.** Another statistic is given from KSSPA database about accidents related to ships in the port waters or others in the port territory.

Table 2. Accident statistics in Klaipeda port in 2003 – 2013.[18]

Date (Year)	**Place of the accident**	**Accident description**
2003	Berth No. 129	Ship sank
	Berth No. 5	Explosives found
	Berth No. 22	Fire on the ship
2004	AB “KLASCO”	Explosives found
	Port waters	Catamaran capsized
	AB “Vakarų laivų gamykla”	Fire in the ship while welding
	AB “Vakarų laivų gamykla”	Fire in the ship

2005	AB “KLASCO”	Fire in the ship
	Berth No. 92	Diesel spill
	Port waters	Fire in the dredger
	UAB “Krovinių terminalas”	Explosives found
	Berth No. 22	Fire in the ship
	Berth No. 102	Fire in the ship
2006	Port waters	Oil spill
	Berth No. 89	Explosives found
	Berth No. 100	Oil spill
2007	Berth No. 98	A car fell into the water
	Dock No. 8	Oil spill
	Berth No. 122	Fire in the ship
2008	Berth No. 118	Oil spill
	Berth No. 80	Fire in the ship
2009	Berth No. 18	Fire in the ship
	Berth No. 130	Oil spill
	Berth No. 66	Explosives found
	Berth No. 66	Explosives found
2010	Berth No. 127A	Fire in the ship
2011	Berth No. 1	Tanker crashed into berth
	Port waters	Ship sunk
	Berth No. 22	Fire in the ships engine room
	Berth No. 53	Ship during the repairs caught fire
	Port waters at berth No. 80	Tanker crashed into floating platform
	Port waters at berth No. 33	Towed ship collides with naval ship
	Port waters at berth No. 1	While loading tanker, oil spill occurred
	Port waters	Ferry ran aground
	Berth No. 70	Fire in ships hold
	Berth No. 56	Fire in the ship
	Berth No. 143a	Explosives found

	LKAB “Klaipedos Smelte”	Explosives found
	Berth No. 122	Fire in the ship
	Berth No. 122	Ships stern flooded
	Berth No. 122	Ships sinking
2012	AB “KLASCO”	Fire in portal crane
	Berth No. 23	Fire in the ship
	Berth No. 59	Ship sunk
	Outer harbor	Fishing boat collides with another ship
	Port waters at Berths No. 81, 82, 95, 96	Oil products spots on the water surface
	AB “Vakarų laivų gamykla”	Oil products spots on the water surface
	Berth No. 122	Fire in the ship
	Port waters	Motorboat ran aground
	Berth No. 80	Fire in the ship
	Berth No. 24	Diesel spill in the ship
2013	Berth No. 65A	Tug sank
	Outer harbor	Fire in the ferry
	Berth No. 122b	Ship sank

From Table 2 it can be seen that besides previously mentioned incidents there is a possibility of environmental damage due to various cargo release as well as economical damage due to ship collisions, grounding or fire. To sum up this subchapter three main risks related to safety of marine operations can be stated in Klaipeda port: risk of human injuries or fatalities while handling cargo, risk of environmental damage due to cargo release into the environment, risk of economical loss due to infrastructural damage and downtimes. In the following subchapter risk treatment plan will be conducted based on principles of risk avoidance, transference, mitigation and acceptance.

4.3. Risk treatment plan for the problem in question

This chapter will review the steps of risk treatment plan which includes: avoidance, acceptance, transference, mitigation. For all three main risks named before, this risk treatment plan will be applied. With respect to that, in the following paragraphs a brief overview will be given about concepts of this particular risk treatment plan.

When risk is assessed, a treatment plan can be executed which involves 4 phases. All these 4 phases clarify how particular risk can be treated depending on the project size, number of parties involved, field of work etc. In this case, large technological process stated as safety of marine operations in Klaipeda port is in question. This process involves many companies, employees and cannot be achieved by only one institution, thus all involved parties must interact with each other in order to get the best results.

Risk avoidance has a function of implementing particular actions before the risk occurs in order to avoid it. Basically, one could say that it is risk elimination in theory, but in real life not everything goes as according to plan, and leads to accident occurrence. For this, second phase of risk treatment plan is carried out known as **Risk mitigation.** When an accident occurs, implementation of mitigation helps to minimize consequences, of course in most companies this is done based on ALARP principle, so analysis of accident frequency and consequences has to be made. **Risk acceptance**, can be referred to such risks like cases of force majeure, mechanical failures due to wear-out etc. These risks are known, but no additional actions are taken, thus risk is accepted. The last part of risk treatment plan is **Risk transference** or outsourcing, which has a meaning of transferring the burden of loss for a risk to another party through legislation, contract or insurance. Today this phase is applied everywhere, since insurance companies are always sought for their services and people want to feel insured about their business, wealth or health.

4.3.1. Risk avoidance

As mentioned in previous subchapter three main risks arises in Klaipeda seaport related to safety of marine operations. In general, to avoid these risks, ships entering the port has to be inspected before. Besides KSSPA and internal shipping companies' interference, another Lithuanian organization has a significant importance in this field. It is the Lithuanian Maritime Safety Administration (MSA), which main activities regarding safety of marine operations includes:

- Development of maritime safety policy, enforcement of maritime safety requirements set by international, European Union and Lithuanian legal acts in ships and shipping companies.
- Assessment of performance of authorized recognized organizations.
- Management of lighthouses and aids to navigation.
- Supervision of inland waterways' specialists and pleasure craft navigators' training.
- Inland waterways vessels accident investigation. Vessels' traffic monitoring. [19]

MSA imposed action list according to the NIR provisions. The operator, agent or master of the ship, which is profiled as High Risk Ship and every passenger ship, oil tanker, gas carrier, chemical tanker, bulk carrier older than 12 years eligible for an expanded inspection shall notify the administration of seaport or sea terminal of the Republic of Lithuania via port information system LUVIS about its arrival at least 72 hours before the expected time of arrival in the port of destination, terminal or anchorage or before the leaving the previous port or anchorage if the voyage is expected to take less than 72 hours, indicating:

- ship identification (name, flag, call sign IMO or MMSI number);
- port of destination; estimated time of arrival (ETA);
- estimated time of departure (ETD);
- planned duration of the call;
- planned operations at the port or anchorage of destination (loading, unloading, other);
- planned statutory survey inspections and substantial maintenance and repair work to be carried out whilst in the port of destination;
- date of last expanded inspection in the Paris MoU region.[20]

All these actions ensure, that ship entering the port will be qualified to do so and risk for any incidents is partly avoided.

Since ship inspections are made before ship entering the port, risk management within port waters is reduced to level of good ship traffic monitoring and regulation as well as cargo handling operations. Ship traffic monitoring and regulation is a task of KSSPA's Vessel Traffic Service department (Figure 9). This department is working 24 hours, every day of the year, with 12 hours changing shifts. Employees include operators-dispatchers, who are talking through the radio with coming and going ships, as well as setting their entering/leaving the port sequence. KSSPA also offers pilot and towing services for ships entering the port, whose captains are not familiar with port waters surroundings. Ships movements are monitored using latest technology which provides real-time data.

Figure 11. KSSPA's Vessel Traffic Service tower.[21]

As mentioned in subchapter 2.2, Klaipeda port is characterized as various cargo handling seaport. Due to diversity of cargoes, different technological processes are applied for each of them. A document stated as "Technological Card" and similar to Job Safety Analysis worksheet is used by every internal shipping company in Klaipeda seaport. This document describes technological process at a specific terminal, ensuring safe and effective work. It includes cargo characteristics, workers' distribution by technological operations, slinging schemes, warehousing scheme, cargo placement in holds scheme, technological process description and safety equipment list. It is clear that based on this document the safety of cargo handling should be ensured, but in most of the accidents as seen in subchapter 4.3, human factor involvement is inevitable, thus accidents still occur.

Another risk while executing cargo handling operations is accidents involving environmental damage, since most part of cargo handled in Klaipeda port is fertilizers and oil products, risk of pollution to the environment from these types of cargo is highest. As mentioned in chapter 4.2, accidents involving human injuries and accidents involving ships are reviewed. In Table 2, there was 8 accidents recorded as oil spills within period of 10 years, which is approximately 15% of all accidents involving ships. This proves that, nevertheless avoidance measures taken by KSSPA, MSA and internal shipping companies, it does not eliminate these risks completely. Therefore, risk mitigation is essential part of risk treatment plan which will be reviewed in the following subchapter.

4.3.2. Risk mitigation

Three main risks were raised concerning safety of marine operations. For each of them different mitigation plans are applied. Firstly, risk of human injuries and fatalities during cargo handling operations will be reviewed.

Common measure to mitigate this risk is to provide first aid, before ambulance comes to the place of accident if needed. In order to achieve this, first aid kits should be placed at every loading station in visible places. Another important measure is good communication between employees and managers, thus managers could be informed as soon as possible and contact the hospital or other relevant institutions.

For the second risk named as risk of environmental damage to due cargo release, mitigation measures include: informing civilians with signaling sirens, contacting KSSPA and other relevant authorities, usage of technical infrastructure to minimize consequences. As mentioned previously 15% of accidents are related to oil spills, thus availability of oil collection facilities is essential. In the table 3 accidents involving oil spills into the port waters recorded since 2005 according to KSSPA is showed.

Table 3 Information about oil spill incidents in port waters since 2005 - 2010[22]

No.	Place of incident	Ship name	Incident date	Amount of contaminants collected
1	Berth No. 92	Keto	2005-02-20	Diesel – 71 liters
2	Berth No. 69	Amalia	2005-11-12	Oil products – 10 m^3 Oil emulsions – 28 m^3

3	Berth No. 97	Karma	2006-01-25	Oil emulsion – 19 m^3
4	Berth No. 100	Frio Roma	2006-10-21	Fuel oil – 0,403 m^3 Oil emulsions – 15 m^3
5	Dock No. 8	Kaduna	2007-05-07	Fuel oil – 0.223 m^3 Oil emulsions – 18 m^3
6	Berth No. 118	Heron	2008-01-21	Diesel emulsions – 33 m^3
7	Berth No. 130	Queen of Scandinavia	2010-03-26	Oil products – 10.2 m^3
8	Berth No. 139	Mount Kent	2010-03-26	Oil emulsions – 54 m^3
9	Berth No. 22	Šernai	2010-08-18	Oil emulsions – 2 m^3

As seen from Table 3, in the period of 5 years a total of 189 cubic meters of various oil products and emulsions has been collected from port waters. This amount may not seem relatively high during this time period compared to the largest oil spills like Deep Water Horizon (780,000 m^3)[23] in history, but according to Bautista and Rahman (2016): "There is no clear relationship between the amount of oil in the aquatic environment and the likely impact on biodiversity. A smaller spill at the wrong time/wrong season and in a sensitive environment may prove much more harmful than a larger spill at another time of the year in another or even the same environment."[24] This proves that no matter the amounts, damages done to the environment after oil spills are indisputable. It is not stated in KSSPA's report how much of oil products has been released totally, only the amounts that have been collected. But from the report it can be stated that, this risk is mitigated accordingly. The process in question can be seen in Figure 12.

Figure 12. Oil spill collection in Klaipeda port waters.

Third risk identified as economical loss due to damages to infrastructure and downtimes is mitigated by good communication (informing managers of the company and KSSPA about the accident soon after its occurrence), company's ability to fix the technical issue as soon as possible (trained staff and backing machinery), KSSPA's ability to fix port infrastructure as soon as possible. The main mitigation plan for this issue is good timing and reporting, since internal company is obligated to fix their own infrastructure, whereas KSSPA is obliged to fix berthing infrastructure as long as they are informed about these problems by internal shipping companies.

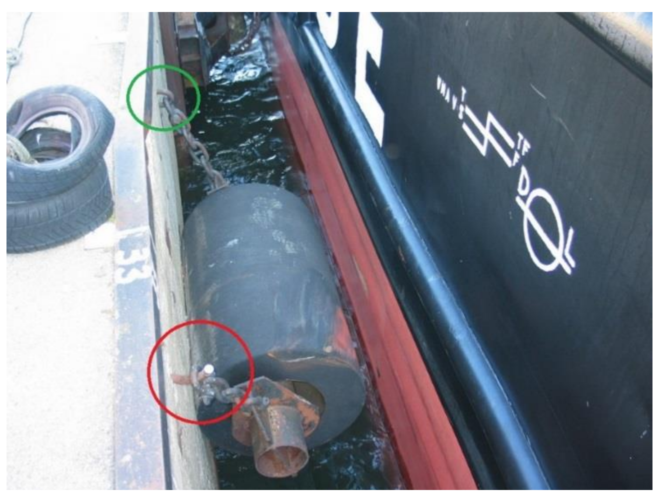


Figure 13. Metal loop broken on which rubber fender is hanged

For example, Figure 13 shows how one metal loop on which rubber fender is hanged with chains, is broken. This is a violation of regulations, by one of the shipping companies, which operates at a particular berth, since a ship nearby can be seen, thus leads to conclusion that KSSPA was not informed before and could not fix the issue before ship came into the port. This kind of violations most of the time are reported by internal shipping companies, but sometimes not, in order not to create downtimes both - for the ship and the company due to repairs. If KSSPA's staff finds out about these violations before they were reported, internal company in question is given penalty fees. Therefore, one of the essential parts of risk mitigation is reporting.

4.3.3. Risk transference

Another part of risk treatment plan is outsourcing or transference. Taking into considerations that first two parts of the process fail, thus consequences are inevitable, employees and all the infrastructure is insured by insurance companies. In general ship insurance, insurance companies provide these services from these risks:

- shipwreck, damage to ship or theft, during navigational season and/or storage time
- ship collisions with other ships or property
- damage to individuals or their property
- environmental damage and other risks.

This is general insurance policy more related to private ships like yachts, motorboats etc. But also, may be applied for commercial ships. Only difference is that it is a matter of ships operator. Based on regulations, cargo carrier is responsible for any damages done to cargo or loss during shipping period. When cargo is warehoused at the port, responsibility for any damages or loss is shipping companies, in whose storages cargo is warehoused. In my personal experience working in Klaipeda port, storage full of di-ammonium phosphate pellets (pesticides) around 15 thousand tones, was mixed with grain, because at the top of the storage grain was transported to the following storage using conveyor line. Since this line was not covered, and whole 8 compartment warehouse is specifically used for agricultural products, grain wastage from the line to DAP compartment occurred. When loading of pesticides to the ship started, client was dissatisfied because of ruined product, and additional workers were ordered to hand pick grain from pesticides, as well as monetary fee was demanded. This situation shows how sometimes warehoused product may be ruined and client has every right to ask damage compensation.

4.3.4. Risk acceptance

The last part of risk treatment process is risk acceptance. In this case acceptance is related to weather conditions and mechanical wear outs in port infrastructure. These risks are known and accepted since, previously reviewed methods cannot be applied or is too costly. No statistical data is given by KSSPA about life expectancies for different infrastructure objects. Therefore, acceptance part will be narrowed down to weather conditions. By given data from port authority of meteorological conditions through period of 1 year (2015 11 – 2016 11), wind statistic diagrams have been made.

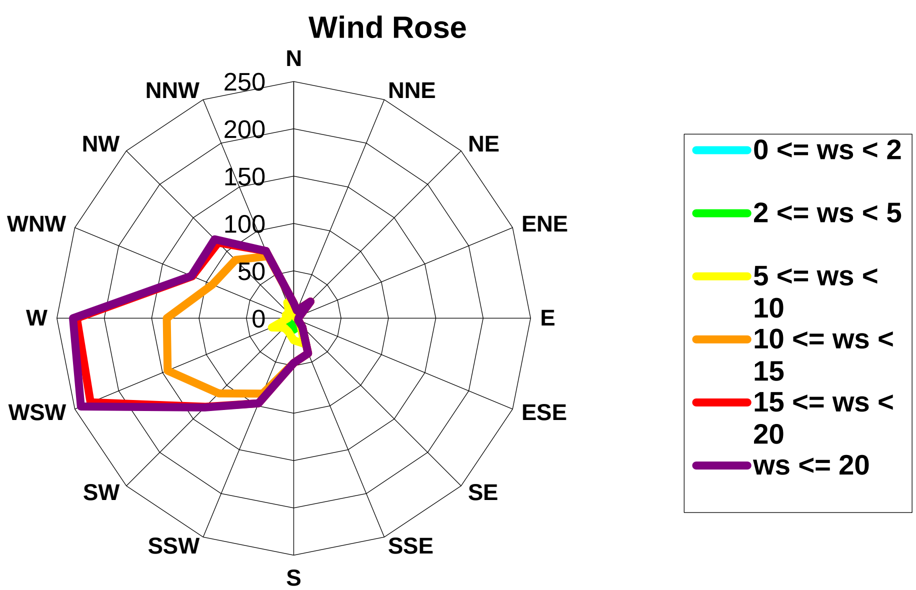


Figure 14. Wind rose of Klaipeda port wind directions and speed through period 2015 11 – 2016 11.

Figure 14 shows frequency of wind directions and speed in Klaipeda port through period of 1 year. It is clear that through this period most common wind direction is west south west, with occurrence of 243 times out of 1190 inputs. Data is recorded every hour, butt was narrowed down to 3 times every 24 hours. As for average wind speeds another diagram was made in order to get a better understanding, since wind directions with lesser speeds cannot be seen clearly in the figure above.

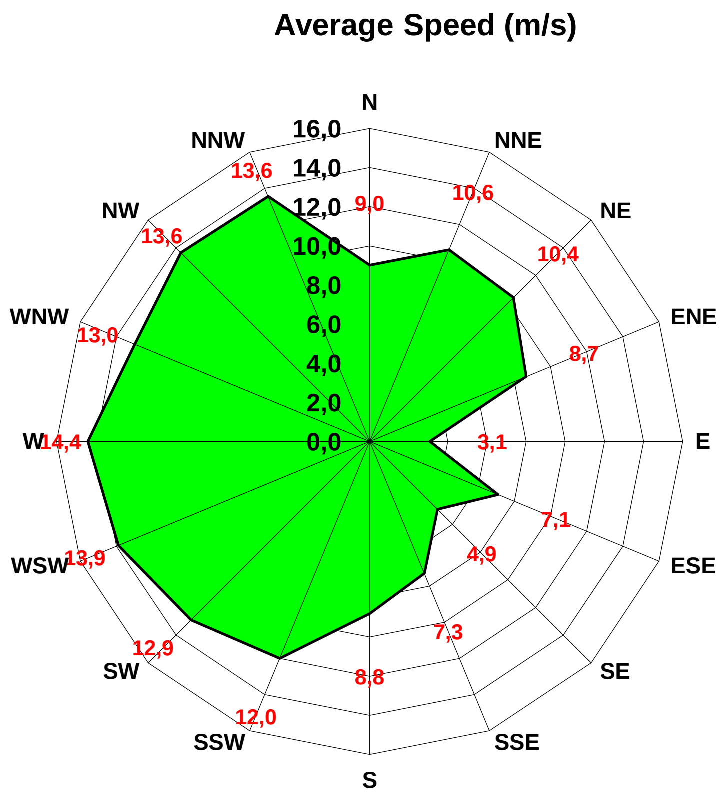
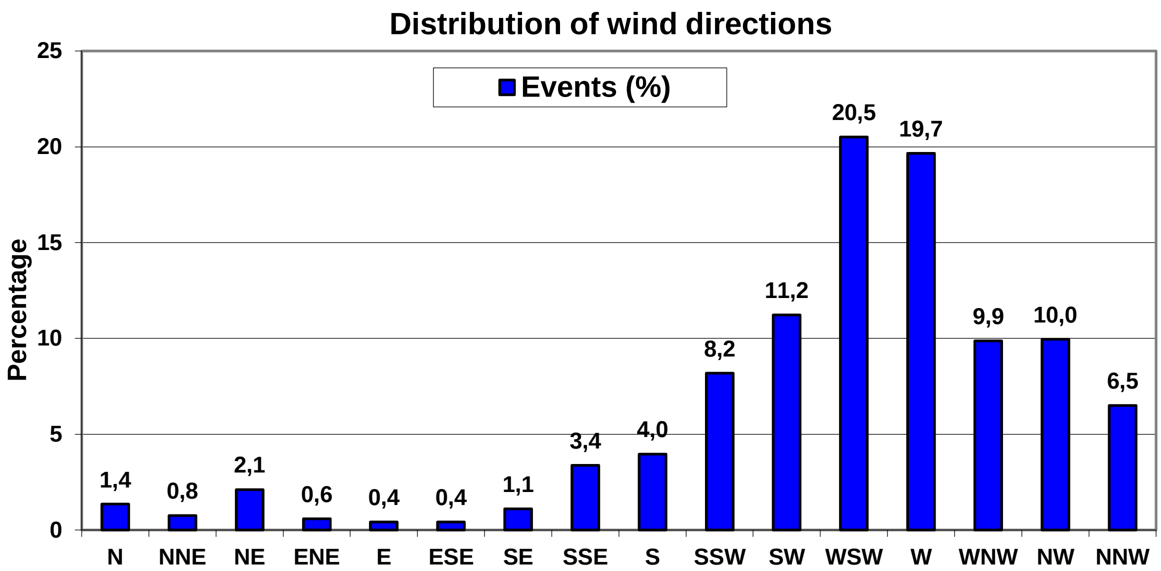


Figure 15. Wind rose with distribution of average wind speeds of Klaipeda port in the periods of 2015 11 - 2016 11.

In the Figure 15, wind rose with distribution of average wind speeds can be seen. From this diagram, it is clear what average wind speeds occur with particular wind directions. On the left side of the wind rose, distribution with higher wind speeds can be seen, whereas on the right side, distribution with lower wind speeds. Main difference between these two wind roses is that one shows which wind directions are dominating, whereas second diagram shows distribution of average wind speeds in particular wind directions.

Lastly two histograms were made in order to specify in percentages how wind speeds and wind directions are distributed in Klaipeda port in the period of 2015 11 – 2016 11. Histograms can be seen in the following page.



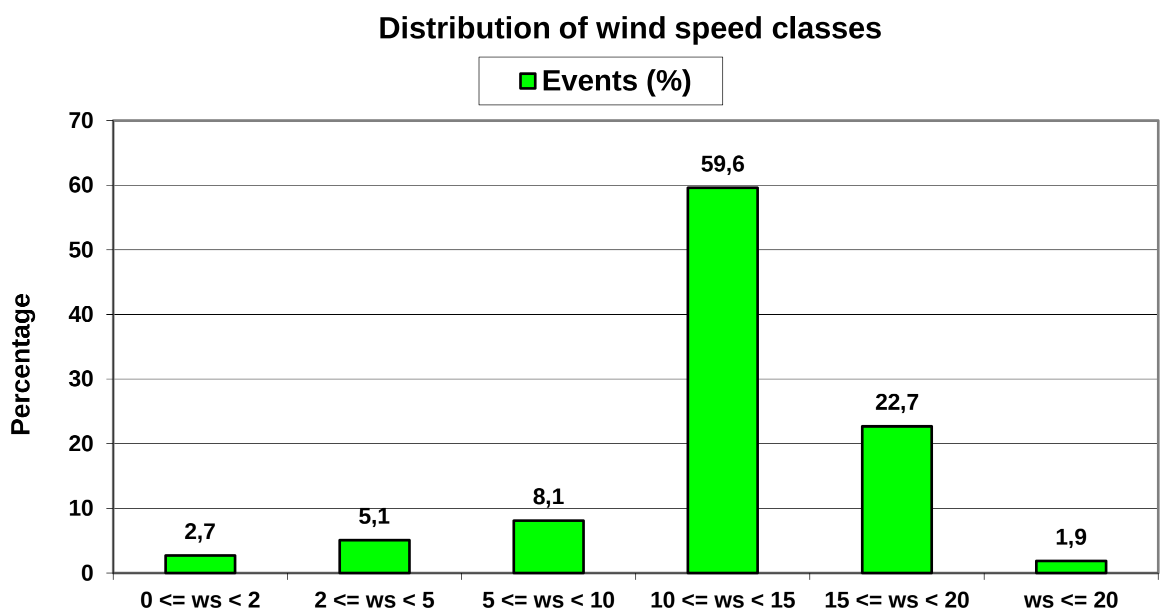


Figure 16. Histograms of distribution of wind directions and wind speed classes

From these two histograms, it is clear that 20.5% of the time, wind direction is west south west, whereas wind speed 59% of the time varies between 10-15 m/s. This data shows that 75.7% of the time marine operations can be executed without any restrictions. But based on regulations in Klaipeda port if wind speeds are between 15-20 m/s, some operations may be limited and if wind speed reaches 20 m/s or is over that, marine operations are stopped and only with harbor masters' authorization ships may enter or leave the port. With respect to this, Klaipeda port stakeholders has to accept the risk of 1.9% of total working time per year might be stopped due to harsh weather conditions. For particular companies' which are handling bulk cargo, rain has also big influence, thus additional risk is added. To conclude, it could be said that weather conditions is a risk factor that while achieving safety of marine operations in Klaipeda port, cannot be eliminated. Therefore, internal and external shipping companies, incoming ships should always keep in mind this and be prepared for downtimes.

4.4. Application of FMEA

FMEA is known as a systematic procedure for the analysis of a system to identify the potential failure modes, their causes and effects on system performance. It is vitally important to know that a failure mode is not the cause of a failure, but the way in which a failure has occurred. (Hoseynabadi et al., 2010). In this case attention is given to safety of marine operations in Klaipeda port, thus accident statistics is going to be used from Table 3, to create appropriate analysis. All the accidents stated in Table 3 can be divided into 6 groups with their frequency as shown in Figure 17.

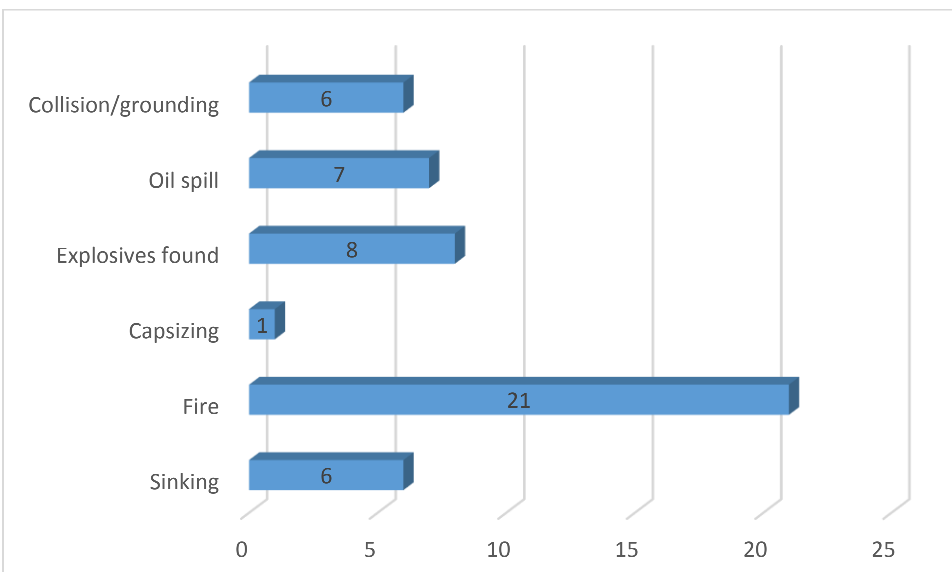


Figure 17. Accident frequency, based on the type of the accident in Klaipeda port 2003 – 2013.

Every accident will be used as a separate failure mode of the marine operations function in the analysis. Since fertilizers and grain takes up to 42% of totally handled cargo (Figure 4) it will be taken as a separate function named as dry bulk cargo handling. Failure modes for the dry bulk cargo handling function will be derived from possible accidents.

Failure mode and effect analysis will be used by following these steps:

1. Identification of failure modes.
2. Identification of consequences for each failure mode.
3. Rating the severity (S) of each effect.
4. Identification of potential root causes for each failure mode.
5. Rating the probability of occurrence (O) for each root cause.
6. Identification of process controls and indicators.
7. Rating the detectability (D) of each mode/root cause.
8. Calculating risk priority number (S*O*D).
9. Design change suggestions to mitigate high risk or highly critical failures and reassessment.

Occurrence and detectability values will be chosen from 1 to 10, with 1 meaning the best option and 10 the worst. Values meaning for severity, occurrence and detection can be seen in Tables 5 and 6.

Table 4. Detection values explanation

Rank	Effect	Criteria: detection of effect on process
10	Extremely unlikely	Controls will almost certainly not able to detect the existence of a defect.
9	Remote likelihood	Defect is detectable after operation & port operators won’t be able to correct it
8	Very low likelihood	Port/ship operators will be able to correct the defect with limitations after operation
7	Low likelihood	Port/ship operators will be able to correct the defect after operation
6	Moderate low likelihood	Port/ship operators will be able to correct the defect during operation
5	Medium likelihood	Controls have medium effectiveness for detection
4	Moderate high likelihood	Defect is detectable prior operation
3	High likelihood	Controls have high effectiveness for detection prior operation
2	Very high	Controls have a very high probability of detecting the existence of delay prior operation
1	Extremely likely	Controls will almost certainly detect the existence of the defect and correct it

Table 5. Occurrence values explanation

Rank	Likelihood of failure	Criteria: occurrence of causes-incidents per items
10 9 8 7	Very High High	>36% 30-36% 24-30% 18-24%
6 5 4	Moderate	12-18% 6-12% 3-6%
3 2	Low	1.5-3% <1.5%
1	Very low	Failure is eliminated through preventive control

Severity values will be taken from 1 to 5 with 1 as insignificant severity and 5 meaning catastrophic consequences. Values meaning can be seen in Table 7, which is taken from Klaipeda State Seaport Authority accident class identification table. For FMEA analysis consequence is referred as severity in Table 7. While performing the analysis these factors will be taken into account by taking each number from every class and calculating the average for each failure mode.

Consequences to humans	
Class	**Characteristics**
1. Insignificant	Conditional discomfort
2. Limited	Small wounds, long term discomfort
3. Serious	Few serious injuries, serious work environment disruptions
4. Very Serious	More than 5 fatalities, around 20 serious injuries, up to 500 evacuated.
5. Catastrophe	More than 20 fatalities, hundreds with serious injuries, more than 500 evacuated.
Consequences to the environment	
Class	**Characteristics**
1. Insignificant	Environment uncontaminated, consequences localized
2. Limited	Minor pollution, consequences localized

3. Serious	Minor pollution, consequences localized
4. Very serious	High pollution, elevating consequences
5. Catastrophe	Very high pollution, elevating consequences
Consequences to property	
Class	**Total loss, mln. Eur.**
1. Insignificant	0.3
2. Limited	0.3-1
3. Serious	1-5
4. Very serious	5-20
5. Catastrophe	More than 20

As for the dry bulk cargo handling function, failure modes severity, frequency and detection will be taken as possibilities in general because no such statistical data was given by port authority. Nevertheless, weather conditions will be taken into account from Figure 16, which means 1.9% of time due to harsh weather conditions dry bulk cargo handling operations cannot be executed.

4.4.1. Failure modes and effect analysis

A simplified table is created based on general model of FMEA, where for each function, several failure modes are proposed with their severity, occurrence and detection. In the last column risk priority number is calculated. The table will show what are the most acute problems during safety of marine operations with their causes. Failure modes and their occurrence values will be taken based on the 10-year accident statistic shown in Figure 16, whereas detection and severity values will be chosen by using brainstorming, since no relevant data is provided by Klaipeda port State Authority.

Table 6. Failure mode and effect analysis

Line	Function	Failure Mode	Effects of Failure	Severity	Cause of Failure	Occurrence	Controls	Detection	RPN
1	Safety of marine operations	Collision/grounding	Damage to ships	4	Bad ship navigation	6	Ship's crew	5	120
				4	Ship's technical problem	6	Ship's crew	7	168
				4	Weather conditions	3	Meteorological organization	1	12
				5	Hijacking	1	Ship's operators/crew	7	35
2	Safety of marine operations	Collision/grounding	Damage to port infrastructure	4	Bad ship navigation	6	Ship's crew	1	24
				4	Bad vessel traffic agency navigation	1	Vessel traffic agency	2	8
				4	Weather conditions	3	Meteorological organization	1	12
3	Safety of marine operations	Collision/grounding	Environmental damage	4	Bad ship navigation	6	Ship's crew	5	120
				4	Ship's technical problem	6	Ship's crew	7	168
				4	Weather conditions	3	Meteorological organization	1	12

	Safety of marine operations	Oil spill	Environmental damage	4	Collision/grounding	6	Ship's crew; Environmental accidents elimination institutions	8	192
				4	Cargo handling operation systems malfunction	6	Port operators	3	72
4	Safety of marine operations	Explosives found (possible explosion)	Damage to port infrastructure	5	Bad port territory inspection, before renting it out.	6	Port authority	5	150
			Human injuries/fatalities	5		6	Port authority	5	150
			Environmental damage	5		6	Port authority	5	150
5	Safety of marine operations	Capsizing	Damage to ship	5	Ship's technical problem	1	Ship's crew	10	50
				5	Bad ship navigation	1	Ship's crew	5	25
				5	Bad weather conditions	1	Meteorological organizations	1	5
			Injuries/fatalities	5	Bad emergency preparedness	1	Ship's crew	8	40
			Environmental damage	4	Fuel leak	1	Environmental accidents elimination institutions	9	36
6	Safety of marine operations	Fire	Damage to ship	4	Ship's technical problem	10	Ship's crew	7	280
				4	Human error	10	Ship's crew	5	200
			Damage to port infrastructure	4	Human error	10	Port operators	4	160
				4	Port technical problem	10	Port operators	3	120

			Injuries/fatalities	5	Bad emergency preparedness	2	Ship’s crew/port operators	6	60
6	Safety of marine operations	Sinking	Damage to ship	5	Ship’s technical problem	6	Ship’s crew	3	90
				4	Bad weather conditions	1	Meteorological organization	1	4
				4	Collision	6	Ship’s crew	4	96
			Environmental damage	4	Damage to fuel tanks	6	Environmental accidents elimination institutions	8	192
			Injuries/fatalities	5	Bad emergency preparedness	1	Ship’s crew	8	40
8	Safety of dry bulk cargo handling	Damage to cargo/infrastructure	Inability to deliver cargo on time	4	Equipment technical failure	2	Supervision	3	24
				4	Operator error	3	Supervision	5	60
				4	Weather conditions	1	Meteorological organization	1	4
	Safety of dry bulk cargo handling	Human injuries/fatalities	Economical loss, downtimes	5	Equipment technical failure	10	Supervision	3	150
				5	Operator error	10	Supervision	7	350

Based on Table 6, histogram is made using cause of failure and calculated risk priority number, which can be seen on the next page in Figure 18. This is done for pointing out the most relevant cause of failure for different failure modes.

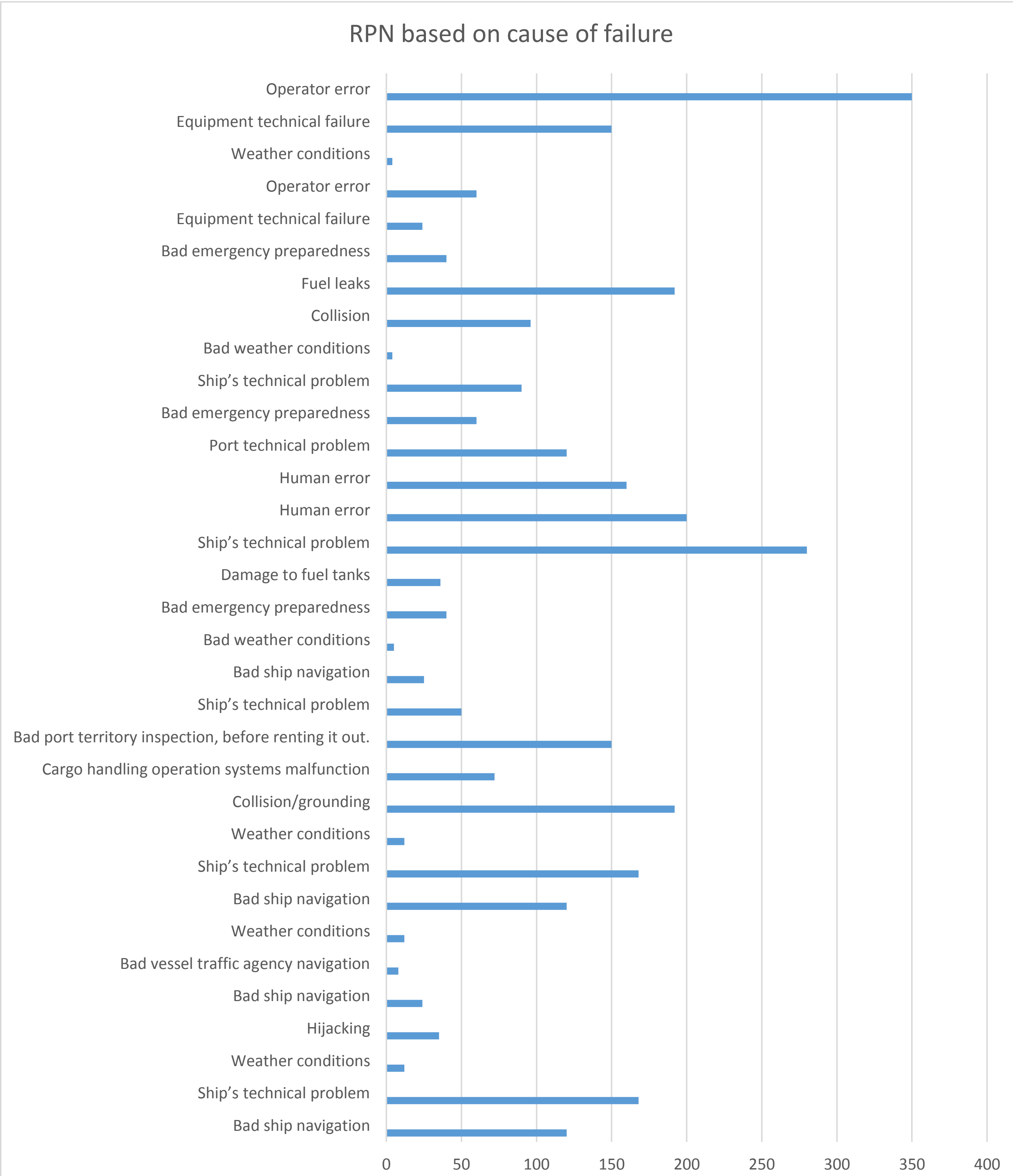


Figure 18. Cause of failure and RPN correlation from FMEA

As it can be seen from Figure 17, several causes of failures stand out from the histogram:

- Operator error for failure mode Human injuries/fatalities with RPN 350 during dry bulk cargo handling.
- Ship's technical problem for failure mode Fire with RPN 280 while conducting marine operations overall.
- Collision/grounding for failure mode Oil Spill with RPN 192 while conducting marine operations overall.

For identified problems bow-tie method will be applied, since they are the most acute problems found out from the failure mode and effect analysis. With the bow-tie method on the left all possible threats are shown, whereas on the right consequences and aftermath is shown. Failure mode will be put in the middle and shown as top event/hazard.

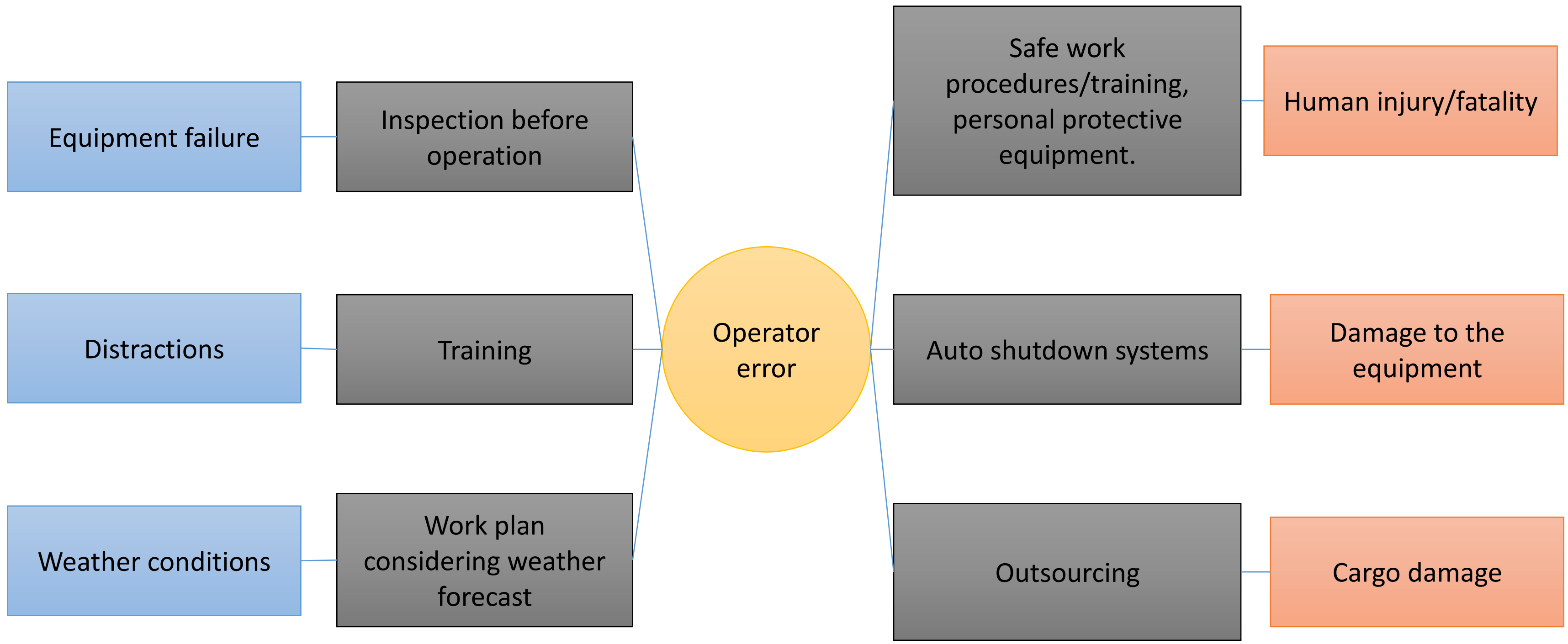


Figure 19. Bow-tie of dry bulk cargo handling, with top event Operator Error.

Figure 19 shows possible threats and aftermath during operator error hazardous event while handling dry bulk cargo. On the left side threats like equipment failure, distractions, weather conditions can be seen with relevant barriers for these threats. On the right side of the bow tie, possible consequences for the top event is shown with relevant barriers. Human injury/fatality, damage to the equipment, cargo damage – these are the consequences which may occur. The most acute one is human injury/fatality, therefore additional preventive measures should be implied in the port companies. Safe work procedures, constant training and supply of personal protective equipment should act as number 1 priority. Damage to the equipment might be avoided by installing auto shutdown systems, as for the cargo damage the best solution will be outsourcing by insurance companies. In the next page bow tie for second most acute problem from the FMEA is made.

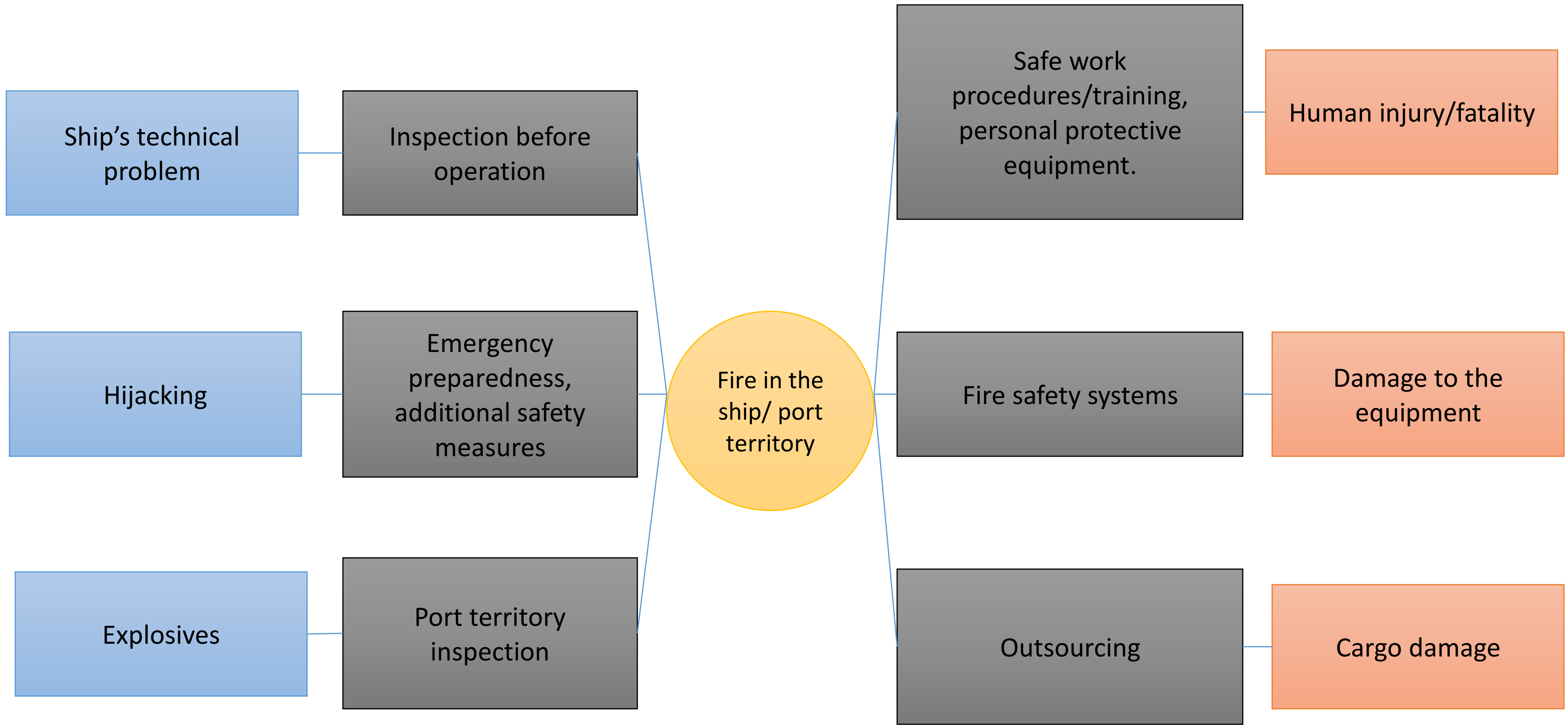


Figure 20. Bow-tie of Fire in the ship/port territory while conducting marine operations overall

Figure 20 shows bow-tie method for event of Fire while conducting marine operations overall. Main threats that would cause a fire during this process are ship's technical problem, hijacking and found explosives. As for the consequences, the most acute problem is human injury/fatality, because if a fire occurred in the port territory or in the ship, depending on the place the outcome could be catastrophic. It is so because oil products and combustible fertilizers and other cargoes are handled in the port. Combustion elevation rate of these materials are very high, therefore simple fire could lead to an explosion and damages would be incalculable both for the port and the city. Third bow-tie for the oil spills is shown in the next page.

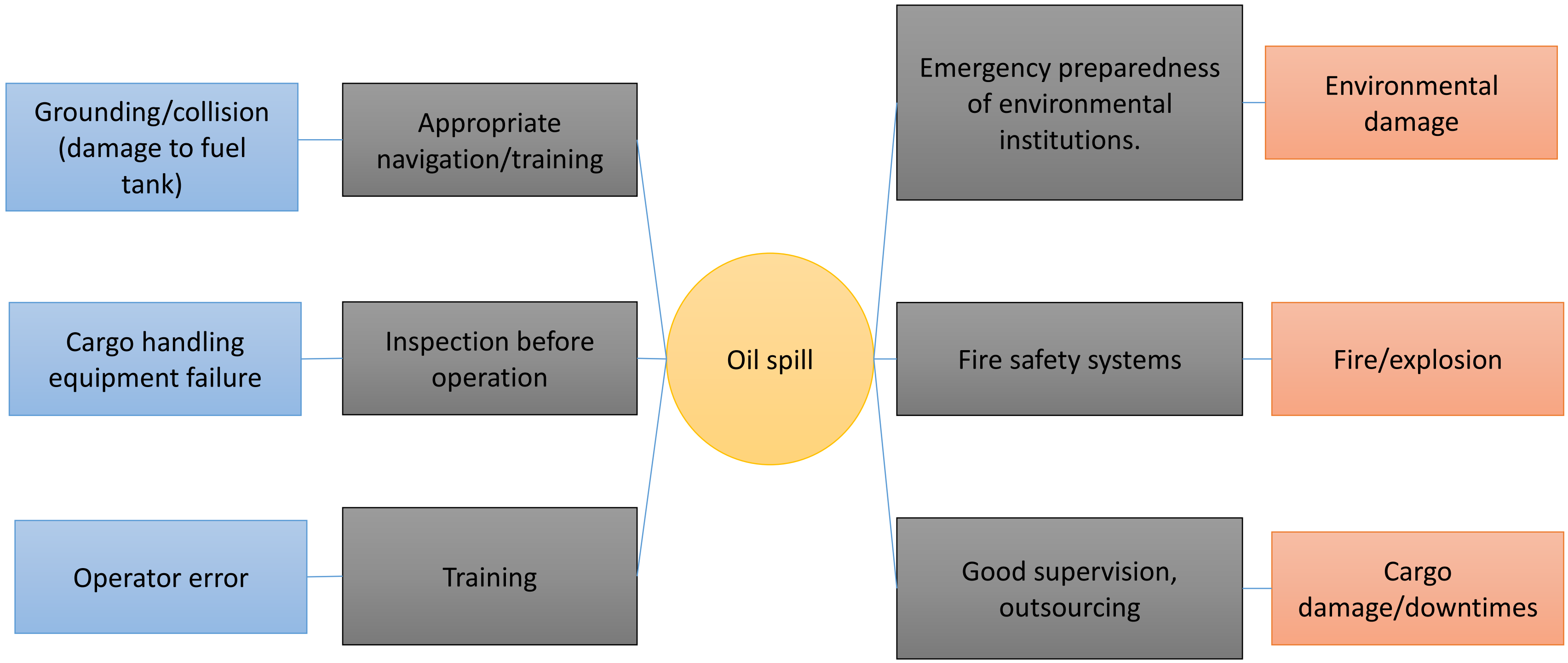


Figure 21. Bow-tie for Oil spill while conducting marine operations overall.

Figure 21 shows bow-tie of Oil spill as a top event while conducting marine operations overall. Main three threats were identified: damage to fuel tank, equipment failure and operator error. For each of the threats barriers are assigned accordingly. Based on the provided accident statistics of the period from 2003 till 2013, 7 oil spills appeared in Klaipeda port. During these accidents, most damage goes to the environment since not all oil products can be collected. Therefore, fast response and good emergency preparedness should be guaranteed by port authority. To avoid oil spills overall, training of ship's crew is mandatory, since it can be considered that the most frequent reason for oil spill is collision grounding which usually means operator error and bad navigation. These factors include human error and rare cases are due to mechanical issues. No data of fire/explosion in Klaipeda port is given, due to an oil spill but still it cannot be removed from the list as possible consequence. Cargo damage and downtimes should be controlled by good supervision in the port companies and outsourcing by insurance companies.

FMEA analysis and application of bow-tie for the three most acute problems, leads to conclusions about general situation in Klaipeda port, based on the accident statistics and usage of brainstorming.

5. Conclusion

In this document "Klaipeda port risk assessment concerning safety of marine operations", a risk assessment was made using risk management plan based on ISO 31000. Firstly, an overview about Klaipeda port was given, including cargo handling dynamics and port characteristics in chapter 2, followed by problem formulation using PBL model used in Aalborg university. Through-out the analysis in chapter 4, main problem sub-questions were answered by identification of stakeholders, analyzing why safety is an important factor during marine operations some of the accidents were overview involving human injuries, fatalities, economical loss and environment contamination. In the last subchapter FMEA analysis was made and bow-tie method application included.

According to ISO 31000 risk management plan, in chapter 4 risk treatment plan was executed. It was concluded that in Klaipeda Port risks and various hazards are assessed respectively using four steps of risk treatment plan. Additional risk management methods are applied in internal shipping companies differently, since different cargoes are handled. For example, every stevedoring company uses "Technological Card" for each cargo handling operation, which is similar to Job Safety Analysis.

For a better emphasis which of the problems are the most acute ones, FMEA analysis was made. From the analysis three main problems were found: Human injuries/fatalities during dry bulk cargo handling, fire either in the ship or port territory and oil spills. For each problem bow-tie method was applied with possible threats and consequences. Based on FMEA the most acute problem is human injuries/fatalities during dry bulk cargo handling, since its occurrence is frequent based on the accident information provided by State Labor Inspectorate, as well as accident severity. Fire and oil spills also occurs relatively frequently, but the severity of these accidents is not so high.

Final conclusion suggests that, overall safety of marine operations in Klaipeda port is ensured, since up to date technology, reporting and working equipment for the employees are provided. Klaipeda State Sea Port Authority and Lithuanian Maritime Safety Association ensures emergency preparedness as well as are collaborating with Klaipeda Municipality and internal shipping companies to achieve good organizational flow. Nevertheless, more than half of the accidents that appeared in the port territory which involved human injuries, resulted in fatalities. This means that supervision, training and emergency preparedness has to be improved in operations which involves direct human intervention.

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