EFFECTS OF RISK MANAGEMENT PRACTICES FOR PREVENTION OF FERRY ACCIDENTS

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PÎRÎ REİS UNIVERSITY

2020

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M.Sc. THESIS

2020

EFFECTS OF RISK MANAGEMENT PRACTICES FOR PREVENTION OF FERRY ACCIDENTS

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M.Sc. Maritime Transportation and Management Engineering,
Piri Reis University, 2020

Submitted to the Institute for Graduate Studies in
Science and Engineering in partial fulfillment of
the requirements for the degree of
Master of Science

Graduate Program in Maritime Transportation and Management Engineering
Piri Reis University
2020

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Date of Approval: 13th January 2020

ABSTRACT

EFFECTS OF RISK MANAGEMENT PRACTICES FOR PREVENTION OF FERRY ACCIDENTS

The navigation through sea is different from the ones happened over a road. These specific differences present at sea are various risk factors on ships. The sea environment encounters with many different accidents because of ships. Serious problems can arise in the environment due to the effects of which are caused by the ships. In this manner, it is an important research approach to reduce the accidents that occur in the sea, to prevent the loss of life and property, and to provide solutions to prevent environmental disasters that can occur in the event of an accident.

Among the other types of vessels, Ferryboats provide a critical mode of transportation for especially within rivers and close sea areas that have no bridge on it and in archipelagic islands. Ferryboats are very special type of vessels because they make people-based transportation. In such ships, even small accidents can cause great loss of life. As associated with the explanations, subject of this dissertation study is associated with ferry accidents. In detail, the study aims to focus on applying the risk management in ferry accidents at sea. Within this aim, ferry accidents have been explained in detail and more consideration was given to the benefits of applying risk management approaches to overcome the issues regarding to ferry accidents occurred at sea. In this thesis study, the international legislation in this subject and the methods developed up to this date are examined and the importance of applying risk management approaches to remove / reduce the causes of ferry accidents is mentioned. At this point, the problems were evaluated separately in the conditions of World and Turkey. Through the study, it has been examined the recent literature in detail and tried to provide a comprehensive reference for the researchers interested in the related subject / sub-subjects of the study.

Keywords: ferry, ferry accidents, risk management, applications of risk management

ÖZET

FERİBOT KAZALARININ ÖNLENMESİNDE RİSK YÖNETİMİ UYGULANMASININ ETKİLERİ

Deniz seyrüseferlerinin bir kara taşımacılığı ulaşımından çok farklı olduğu aşikârdır. Denizde mevcut olan bu spesifik farklılıklar gemiler üzerinde çeşitli risk faktörleri içermektedir. Deniz ortamında gemilerin neden olduğu birçok kaza yaşanmakta, bu kazalar sonucunda çevre üzerinde de ciddi problemler oluşmaktadır. Bu şartlar altında denizde meydana gelen kazaları azaltmak, can ve mal kaybının önüne geçmek, kaza neticesinde oluşabilecek çevre felaketlerini engellemek için çözüm üretmek önemli bir araştırma alanı haline gelmiştir.

Diğer deniz araçlarının yanı sıra feribotlar, özellikle nehirlerde ve yakın deniz alanlarında, üzerinde köprüsü olmayan veya olsa da alternatif olarak adalar denizleri için önemli bir ulaşım aracı görevi görmektedir. Feribotlar insan odaklı ulaşım sağlamaları nedeniyle de özel bir önem taşımakta, bu gemilerdeki küçük kazalar bile büyük can kayıplarına neden olabilmektedir. Bu kazaların önlenmesi veya minimize edilmesinde başvurulan çeşitli yöntemler arasında risk yönetiminin özel bir yeri olduğu değerlendirilmektedir. Bu tez çalışmasında bu konudaki uluslararası mevzuat ve bu güne kadar geliştirilmiş olan yöntemler incelenerek yaşanmış olan feribot kazaları ayrıntılı olarak ele alınmış feribot kazalarıyla ilgili sebeplerin ortadan kaldırılması / azaltılması için risk yönetimi yaklaşımlarının uygulanmasının önemi belirtilmiştir. Bu kapsamda dünya ve Türkiye koşullarındaki feribot kazaları ayrı ayrı olay incelemesine tabi tutulmuş ve yapılacak müteakip çalışmalar için referans sağlanmaya çalışılmıştır.

Anahtar Kelimeler: Feribot, Feribot kazaları, Risk yönetimi, Risk yönetimi uygulamaları.

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LIST OF SYMBOLS/ABBREVIATIONS

AFP	Agence France-Press
AIS	Automatic Identification System
ALARP	As Low As Reasonably Practicable
COLREG	International Regulations for Preventing Collisions at Sea
EPA	European Protection Agency
EU	European
FMEA	Failure Mode Effect Analysis
FMEA	Failure Modes, Effects and Analysis
FMECA	Failure Modes, Effects and Critically Analysis
FSA	Formal Safety Assessment
GMDSS	The Global Maritime Distress and Safety System
HAZID	Hazard Identification
HAZOP	Hazard and Operability
HE	Human Error
IACS	The International Association of Classification Societies
IMO	International Maritime Organisation
ISM	International Safety Management
MARPOL 73	Marine Pollution Convention
Mediter.	Mediterranean
MLD	Master Logic Diagram
PHA	Preliminary Hazard Analysis
SAR	Maritime Search and Rescue
SF-BREEZE	San Francisco Bay Renewable Energy Electric Vessel with Zero Emissions
SMS	Safety Management System
SOLAS	Safety of Life at Sea
STCW	Standards for Training, Certification and Watchkeeping for Seafarers
SWIFT	Structured What-If Technique
TSS	Traffic Separation Scheme
UK	United Kingdom
US	United States
VTS	Vessel Traffic Services
WSF	Washington State Ferries

1. INTRODUCTION

Thousands of years ago, people had wanted to explore what was beyond the seas that was seemed almost infinite, long way leading to connections between far landscapes. Like in landscape, the sea is lying there to provide connection among different communities and countries which looks necessary for the humankind to develop and improve themselves to overcome the issues of the modern-life, travel and to solve the mysteries of this “new” world. On the other hand, the sea is also a way of trade between communities through shipment and transportation.

Today, marine transportation still keeps its importance. There are many kinds of ships today and their differences are based on the type of cargo the ship transports such as container ships, auto carriers, tankers, oil vessels, fish vessels, and ferryboats. Among them, ferryboats are the one that transport people from port to port sometimes within long distances, like the Alaskan ferry and mostly in short distances especially where there is no constructed bridge or within archipelago islands. Although ferries offer a safe and a time-saver transportation and primary way in many countries, unfortunate accidents caused by later-defined problems are happening especially in developing countries. Such problems are cause of changing in weather conditions or other issues related to ships, people, or objects carried over these ferries. People are still trying to find out which factors are more important to get optimized results for such problems and they profit by the advantages of the latest technological improvements which are involved in risk management methods. Today, many problems have been solved through these effective solutions while many are still waiting to be solved.

1.1. Significance of the Study

The purpose of this study is to reveal the significance and benefits of risk management to contribute solving problems and prevention of ferry accidents which have already caused many tragic events.

1.2. Methodology

This study is based on the understanding risk management process in general and benefits in prevention of ferry accidents by using an extensive literature review as the first step in Chapter 2, Chapter 3 and Chapter 4.

Based on this review, special effort has spent on some ferry accident cases applying those of methodology as contribution to prevent or ease the effects of those accidents through case studies in Chapter 5.

1.3. Objectives of the Research

The main objective of this study is to focus on ferry accidents and give information about risk management factors to reveal certain solutions, which can be usable to lower and even overcome the problem of ferry accidents. As associated with this objective, the related sub-objectives can be listed / expressed briefly as follows:

- To give brief information about ferry transportation, its history and benefits.
- To evaluate the situation in the context of worldwide and Turkey.
- To provide a risk analysis regarding to marine accidents.
- To discuss the role of risk assessment in maritime industry.
- To comment about putative application of risk management to overcome that problem of ferry accidents by considering the background, and risk analysis.
- To reveal the benefits of such risk management factors that are usable for ferry accidents.

1.4. Contribution of the Research

The research efforts provided within this thesis are essential factors to develop and improve the associated literature. Along the study, the related efforts are associated often with analyzing the most recent literature and focusing on some outputs that can be obtained by thinking about the benefits of applying risk management on the issues related to ferry accidents at sea. When the literature is reviewed, importance of the aim of this study is clarified since there are many examples of ferry accidents in the worldwide but not much information about ferry accidents' risk management. In order to decrease or eliminate ferry accidents, a putative risk analysis and risk management have been done in this research. Additionally; this study is crucial to reveal the benefits of risk management for ferry accidents which are clarified and discussed in the content.

1.5. Outline of the Dissertation

In Chapter 2, a brief literature review is introduced related to the institution, namely IMO which regulates maritime safety management system via its promulgated international regulations in order the following terminologies become well understandable. The fundamental international regulations such as SOLAS Convention and ISM Code are referred as the basic international regulations which are constituted and developed in this contest. Following these basic information on the terminologies such as risk, risk analysis and risk management were described and a risk management method was explained with its benefits.

Chapter 3, a brief information about marine transportation was given, a brief history of ferry transportation and its importance were described.

Chapter 4, basic causes of ferry accidents were explained then examples of ferry accidents from worldwide and from Turkey were expressed.

Chapter 5, Case studies and risk assessment for example of ferry accidents.

Finally, whole concept was discussed and concluded by means of giving benefits of risk management to decrease or eliminate ferry accidents in all over the world.

2. LITERATURE REVIEW ON MARITIME SAFETY AND RISK

2.1. Context of Maritime Safety

Maritime safety is a definition used to describe the safety of life, property and the environment at sea. The avoidance of danger in marine environment is defined as the necessary procedures for elimination of dangerous formation and provision of it [1], [2]. In this context, basic institutions and regulations play key roles.

2.1.1. International Maritime Organization

The International Maritime Organization or simply IMO, was established in 1958, is one of specialized agencies in United Nations which is mainly responsible for safety and security in marine transportation and for prohibiting marine pollution caused by vessels. IMO considers safety, security and environmental performance inside international shipping. The main purpose of IMO is to generate a regulatory model for marine industry which is performed under equitable and effective conditions. IMO regulations are universally adopted and implemented. Today, IMO have 174 Member States and three Associate Members [3].

IMO is the only international regulatory agency in maritime industry and IMO have a key role in shipping industry as it defines the authority to establish safety and quality standards to be succeeded and to be applicable in member-Countries [4].

2.1.2. International Safety Management

IMO which regulates maritime safety management system via its promulgated international regulations. The first and most important legal instrument is SOLAS Convention adopted just after the establishment of IMO.

Since its establishment, IMO has drawn up many instruments such as, codes, contracts, decisions and guidelines etc.in order to build maritime safety all over the world. The majority of them are prepared to reduce the environmental pollution by increasing safety in marine transportation, preventing loss of life and property. Despite all these contracts, guides and decisions, the sea accidents and environmental pollution caused life and property losses have lasted up to day [6]. The major cause of accidents is human factor and in order to get the lowest human factor in the accident, International Safety Management (ISM) should be considered by the maritime companies and based on the facts vessels will be operated [7].

The International Safety Management Code (ISM Code) was adopted on November 4th of 1993, under resolution A.741 (18) of the IMO General Meeting. In May 1994, the International Convention for the Safety of Life at Sea (SOLAS), under the heading "Management for the Safe Operation of Ships" (Chapter IX) Section added [8].

The International Safety Management Code is a guideline that contains international standards and is designed to create a system that enable maritime companies to manage their vessels in a safe and environmentally conscious manner [9].

The IMO has issued the first revision of the Code and its amendments including an important clarification with regard to the relevance of risk assessment to the Code which adopted on 4 th December 2008 and became mandatory on 1 st July 2010. All companies should be aware of these revisions and be taking steps to ensure their compliance. The phases of risk assessment process in basic approach as the core of the total risk management system, which is the fundamental intend of ISM Code even before the recent amendments. The ISM code consists of 13 items. According to these items, companies create safety and environmental protection policies. It is considered that the participation and support of the top management would succeed the ISM Code application. Authorities and responsibilities between the units of the company are determined. For all ship operations, which may pose a risk during its implementation, rules, procedures and instructions shall be established and written and distributed. "Probability Plans" are prepared to take action against potential dangerous events. The ISM Code aims at ensuring safety at sea, preventing people from being injured or losing their lives, and avoiding environmental and material damages. Through ISM Code following steps are aimed [10].

- Providing safe methods and safe working environment in ship operation
- Establishing measures against all specified hazards

- Being prepared for emergencies related with both safety and environmental protection
- Improving the safety management skills of ship and land personnel, continuously.

ISM should take into account the rules, guidelines and standards that are recommended by the IMO, the Administration, the classification society and the maritime industry organizations. Through the classification agencies, it is checked whether the ships and the shipbuilding companies comply with the requirements of the ISM Code. Eligible companies are awarded the "Document of Compliance (DOC)" and for its ships "International Safety Management Certificate (SMC)" [10].

2.1.3. Formal Safety Assessment

Formal Safety Assessment (FSA) is a part of the maritime safety management system. The FSA is a more scientific approach, based on the control and assessment of risks, that needs to be harmonized with ship and port safety, expressing a move towards performance that is far from perspective standards [11].

The ISM Code aims to increase the safety awareness of vessels with the obligation to ship owners Safety Management System (SMS). FSA, on the other hand, aims to develop a regime dependent regime in which vessels are operated. These two approaches complement each other and both would help reduce risk at sea [6], [12].

The FSA begins with the identification of the hazards. Danger can be defined as having the potential to cause damage. This harm can be harmful to people or the environment. The FSA is concerned with assessing the risks associated with these hazards [6]. Figure 2.2. shows the FSA Flowchart [4].

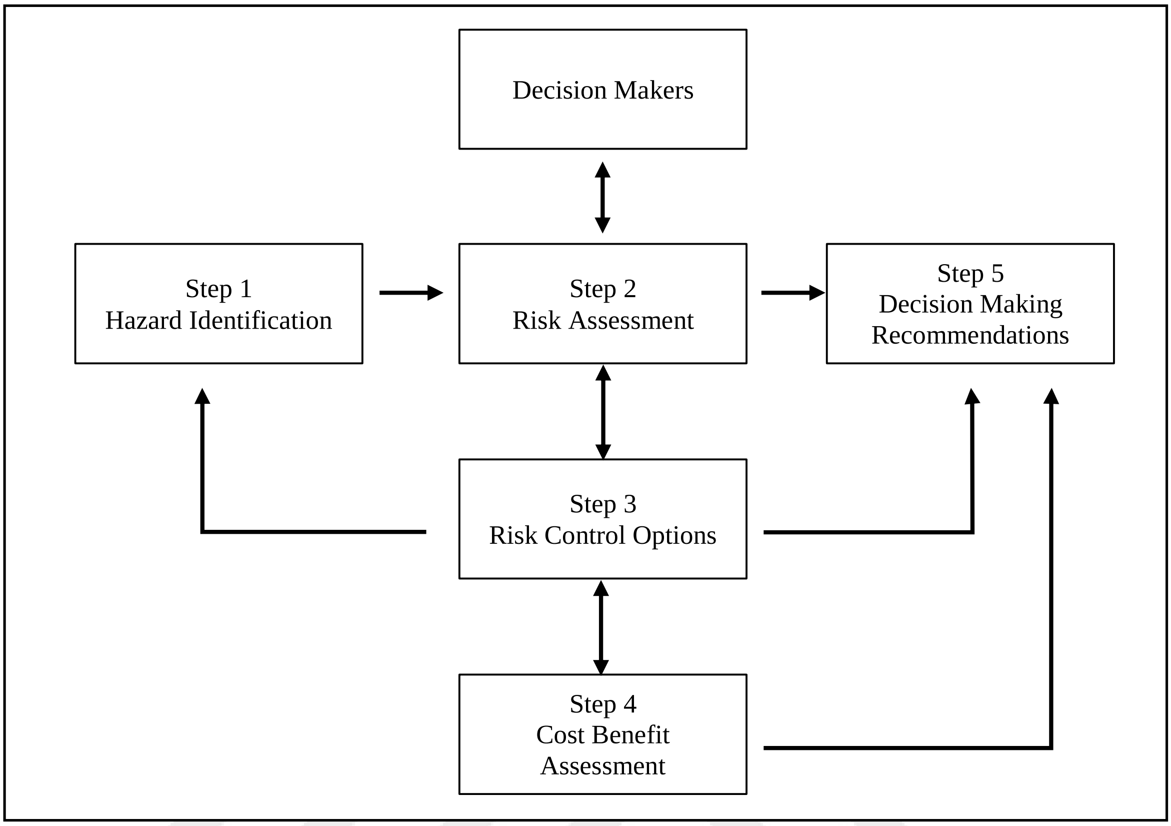

Figure 2.1. FSA Flowchart list of all relevant accident scenarios with their potential causes and consequences. https://nrc-publications.canada.ca

Figure 2.1. FSA Flowchart. FSA contains five steps as follows [9].

- **Identification of hazards**: İncludes content and size of the hazard
- **Risk assessment:** Assessment of risk factors affecting safety
- **Risk control options:** Taking regular measurements to reduce and control certain risks, options to reduce the likelihood of realizing risks and / or possible effects
- **Benefit cost evaluation:** The cost effectiveness of each risk control option, the cost of risk mitigation and the benefit
- **Recommendations for decision making:** Providing information on the risks, the risks associated with them, and the cost-effectiveness of alternative risk control options

2.2. Risk

The term “risk[1]” is defined as “a situation involving exposure to danger” according to Oxford dictionary. To understand the risks, it is firstly needed to define the hazards. Hazards are defined as physical conditions with potential to cause damage. This damage may result in human injury, damage to the ship, overhead, or damage to the environment. These damages may be in the form of fire, explosion, the spread of harmful liquids or gases, the release of radioactive materials, or the sinking of the ships [9], [13].

Many definitions for the term risk have been made. In terms of maritime, the definition for risk is the emergence of danger, that is, the chance of a certain accident occurring within a certain period of time. There are two main parts of risk and these are frequency and severity. Frequency is the probability of an accident happened in a year. The odds are very low in risk analysis. For example, for large accidents, this possibility is known as a chance of a million a year. On the other hand, severity is defined as the expected effects of the accident. In terms of risk analysis, severity is evaluated as the size of the area of the accident and the number of people affected by the accident [9], [14].

Risk is the measure of the two elements of an accident. The first one is the probability of an accident as a result of a hazard such as bad weather conditions do not always cause of accidents, and the other element is the severity of the accident for example, accidents might cause injuries on crew members or the ship might be capsized as a result of accident [9].

Risk is the probability of an undesirable event and its associated bad consequences or losses. This situation requires both qualitative and quantitative risk assessment. If risk measurement is not to be done, many losses related with business, operation and people-related issues would be faced with. Generally, there are three main risk groups are encountered in both ship and land operations. These are health and safety issues, environmental factors and operational factors and all those factors are related with cost-flow (Fig 2.2.). The results of risks can be either injuries or worst situation which is death for health and safety issues, pollution for environmental risks and breakdowns, out-of-rent for operational risks [13].

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[1] “*Risk*”, Oxford Dictionary

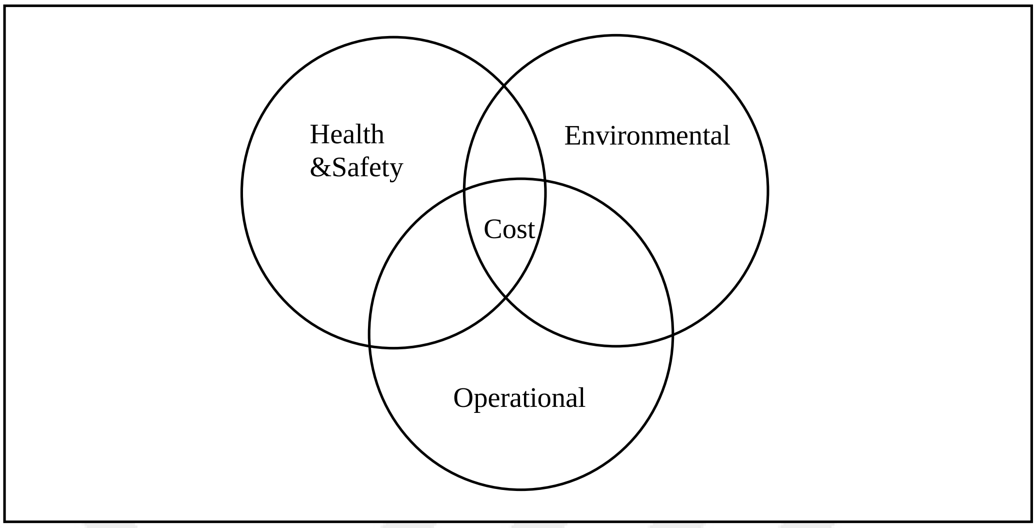

Figure 2.2. Diagram Showing Three Main Risk Groups.

Probability and severity should be investigated and learned correctly. To evaluate risk there is a need for robust data of the losses and probabilities. There is no any databank which involves the information about those possibilities and severities. That's why some categories have been made based on historic analysis of the risk concept. Table 2.1. shows summary of nine categories of risks based on definitions and discussions on how risk used in the application area [15], [16].

Table 2.1. A Classification of Risk Definitions. https://aaltodoc.aalto.fi

	Risk definition classes	**Abbreviation**
D1	Risk=Expected value	R=EV
D2	Risk=Probability of an (undesirable) event	R=P
D3	Risk=Objective uncertainty	R=OU
D4	Risk=Uncertainty	R=u
D5	Risk=Potential/possibility of a loss	R=PO
D6	Risk=Probability and scenarios/(severity of) consequences	R=P&C
D7	Risk=Event or consequence	R=C
D8	Risk=Consequence/damage/severity+uncertainty	R=C&U
D9	Risk=Effect of uncertainty on objectives	R=ISO

Category D1 determines risk as expected value of an accident to occur. In D2, the risk is defined as the probability of an unwanted event. In D3 the risk definition is the objective uncertainty which is known by calculations or statistical data analysis. In D4, the risk is equal to uncertainty whereas D5, risk is equal to the possibility of an unfortunate occurrence. D6 determines risk as the combination of probability of occurrence and scenarios, D7 shows risk as an event or consequence. In D8, risk is defined as the combination of consequence, damage, severity and uncertainty and D9 defines risk as an effect on stated objectives and consequences because of the uncertainty.

2.3. Risk Management

Risk management system is a step-by-step process including of following phases: risk assessment which involves analysis and evaluation, and risk management. Risk analysis is the process of where risk preparations are done by qualifying, quantifying, selecting, identifying and formulating concerned issues, risk generating events and problems. Risk evaluation determines and evaluates the rank of the risk by understanding the magnitude of risk, then through monitoring, risk analysis is made a continuous flow. Each phase includes many stages and steps. The onset of the process is triggered by the combination of certain factors such as the severity of the accidents, threats, problems or concerns, the availability of resources, the presence of additional and / or new data, and developments and / or improvements. The process can start at any point and can include any component of the system. The processes are interactive and steps can be carried out individually. [13].

Efficient risk management system provides managing innovation and enhance performance by contributing to increased precision and less surprise, more efficient management of change and use of resources, better management in making improved decision, reduced waste and casualties, innovation and finally management of unity and maintenance in events and system [13], [17].

Risk management is a systematic way of approaching the control, improvement and identification of threats and risks to earnings and assets. This could include catastrophic disasters such as shipwrecks, machine failures, losses following legal debts, or explosions from oil spills [9].

Risk management also involves a policy that discusses policy management alternatives and implies the following approach by selecting the most appropriate legal action and combining the results of the risk assessment with additional data on social, economic and political concerns such that assessment of chemicals, identification of risk assessment, risk evaluation and risk reduction or mitigation [13]. The process of risk management is shown in Figure 2.3. [9], [13], [18].

Shipbuilder is responsible from technical standard of vessel. Classification society controls the technical standards on behalf of insurer, and undertakes some control functions on behalf of the flag state. Insurer takes the main part of the risk on behalf of the shipper and cargo owner and may undertake independent assessment of the quality of the shipper. Flag State and Coastal State are responsible for controlling the vessel, crew standards and management standards. As last, management company is in charge of crewing, operation and maintenance of the vessel on behalf of the ship-owner (Fig 2.3.) [19].

Risk management requires the analysis and identification of possible hazards. When risks are defined, the risks can be assessed and evaluated as potential magnitude and probability based on the accidents' likelihood of occurring and impact of severity. When all possible risks are defined, plans can be made in the most effective sense by means of to reduce the impact of the risk. Regardless of the planning, effective risk control measures can be passed on and monitored whether the situation has been changed and the possibility of new risks to be emerged (Fig 2.3.) [20].

In the systematic study of possible hazards (or dangers), it is possible to recognize the cost benefit of improved management and to use risk reduction services methods and equipment. The purpose of security measures at sea will be to reduce the risk. Risk level is a combination of probability and severity. Risk assessment includes assessment of frequency and severity at various events to identify the control area. It is also used to determine the probability and severity of the theoretical and actual losses [9], [13], [20].

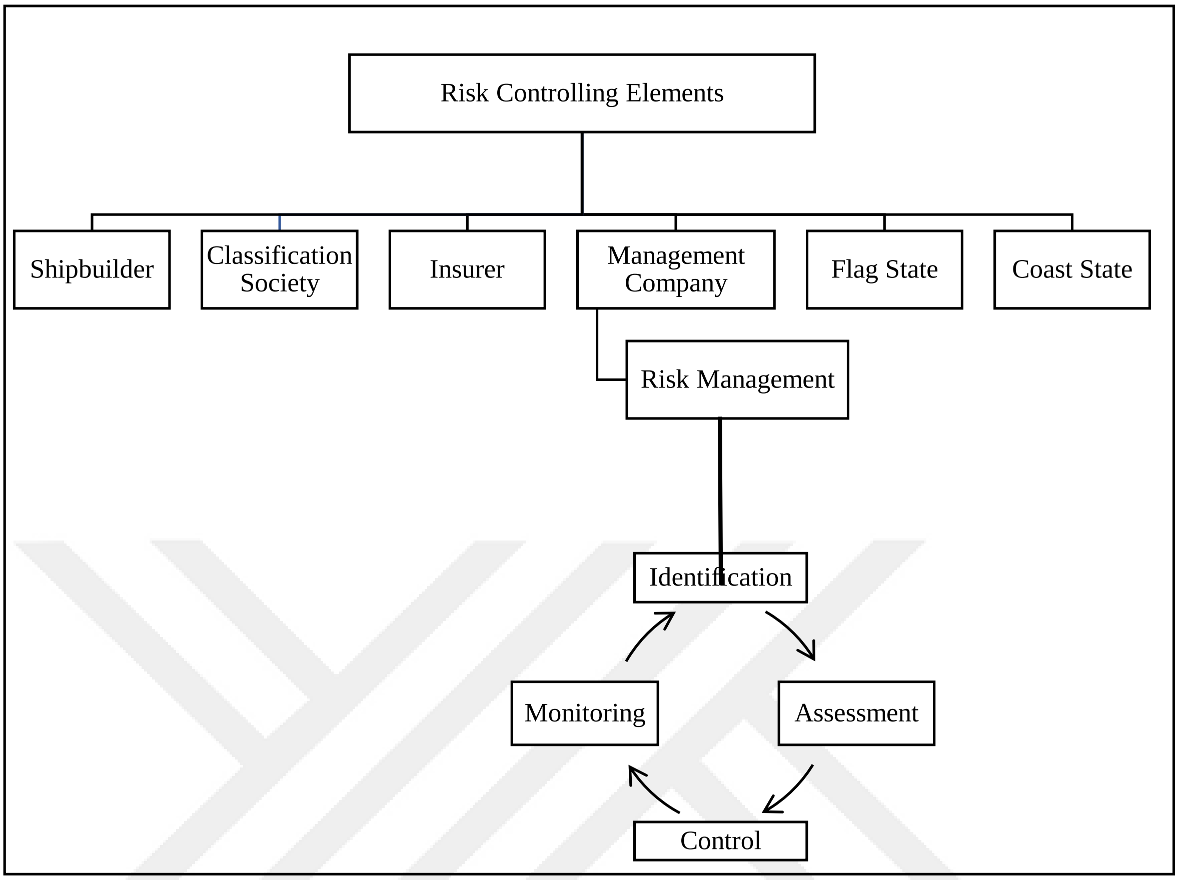

Figure 2.3. The Process of Risk Management.

In the maritime transportation, Failure Mode Effect Analysis (FMEA) affects the interaction of the combined factors that allow the accident to occur, and the revealing of the risk. The benefit of the FMEA is further enhanced by the application of probabilities and data to the model [9], [16], [20].

Based on the type of insurance policy and the amount of rebate, the analysis of past losses, the stage of loss control and the financial situation, the decision can be made not only by broker but also by the ship operator. High severity / low coverage risks can be passed to approve the insurer [12].

2.4. Risk Assessment

Through SMS, it is possible to identify and control risks before they occur. In this respect, risks are primarily assessed. There are two types of risk assessment methods, quantitative and qualitative.

The quantitative method requires a considerable amount of resources to establish a large number of event information and risk assessment levels at different locations. Quantitative techniques are particularly suitable for complex and high-risk programs when available data is available. Techniques such as error and event trees are used for the measurement [13], [19].

On the other hand, the qualitative method uses the risk in a comparative structure to define how much risk an activity has according to another activity. The possibility of undesired events and their consequences; High, medium and low. This classification ensures that risk scenarios with the most impact on the outcome are established. In a port risk assessment, the risk application within a carefully considered comparative method will allow identification of activities at high risk without needing to determine the full value of the risk [13], [19].

Risk assessment provide identifying and minimizing risks. Risk Assessment is where the severity and potential consequences of the hazard are assessed together with other factors such as the level of exposure and the number of persons exposed and the risk of occurrence of this hazard. There are different formulas used to calculate risk, ranging from simple calculations to complex algorithms to calculate risks. Qualitative risk assessment; Particularly large and small ports, are fundamentally the same, although they vary in terms of implementation. Four steps are foreseen for the assessment of the risk to be applied at the port by way of this base [6], [19].

- Collecting Data
- Identification of Hazards (HAZID)
- Risk Analysis
- Determination of Risk Management Strategy

2.4.1. Collecting Data

The data for determining the risks at sea are usually provided from the following sources:

- Previous events, dangerous situations and accident records of the port

- Loss of lives
- Port traffic and trade estimation
- Radar detecting records
- Traffic diversity and routes in the region
- Number and types of ships passing through a certain point
- Types, dimensions and maneuverability of vessels serviced on the port
- Tide conditions at the harbor, wave height and wave period
- Hydrographic and oceanographic information about the harbor
- Depths and potential hazards of the port approach route
- Weather conditions reports of the port
- The dock features in the port, dimensions, height from water level and depth of dock,
- Navigational aids and locations
- Information on services provided on the port
- The situation of pilotage and tugboat services

Based on the collected information, possible hazards of the port and the causes of these hazards would be determined and risk areas would be established at the next stages [19].

Investigation of the causes of accidents described below could be more usable if we had get to whole documents releavent mostly cases explained here. In most countries where ferry accidents are common, no accident investigation or results are ever published

2.4.2. Identification of Hazards

Danger or hazards can be defined as events or events that are likely to harm human health, the environment, or the system and process. This hazard may be due to a physical activity such that dropping in weight that a cryogen cannot carry, from the material used such as fuel oil, a substance that is always a danger of burning. Generally, hazard is a whole of physical and material events that can lead to a failure or error in a process. It is the potential of hazard that the cause of knowledge or knowing is always the potential to cause disruption or failure. So, every danger and hazard is a risk. The Hazard Identification is the first step in the risk assessment methodology, as it is understood from its name, as it is a method of making the definition of hazards. There are two basic methods of defining the hazards [20].

- Listing the hazards for the determination of the risk assessment methods used. This process is sometimes called “failure case selection”.
- To make a qualitative assessment of the likelihood of the occurrence of hazards and to separate the risks from these hazards. This process is sometimes called “hazard assessment”. Figure 2.4. shows a schematic representation of the implementation of hazard identification methods [20].

Hazard identification methods are listed below [21].

- **Hazard Log:** Tool to record information about hazards and hazardous events in order to keep updated data.
- **Checklist and Brainstorming:** Preparing a list of extensive hazards and hazardous events is useful in order to consider all possible events that may exist in the future.
- **Preliminary Hazard Analysis (PHA):** PHA is a method used to identify hazards in the design phase of a system. It is called as preliminary since its results are often updated as more risk analyses are followed through. PHA is also used in later phases of events because of its complete and sufficient risk analysis. PHA is also called as HAZID.

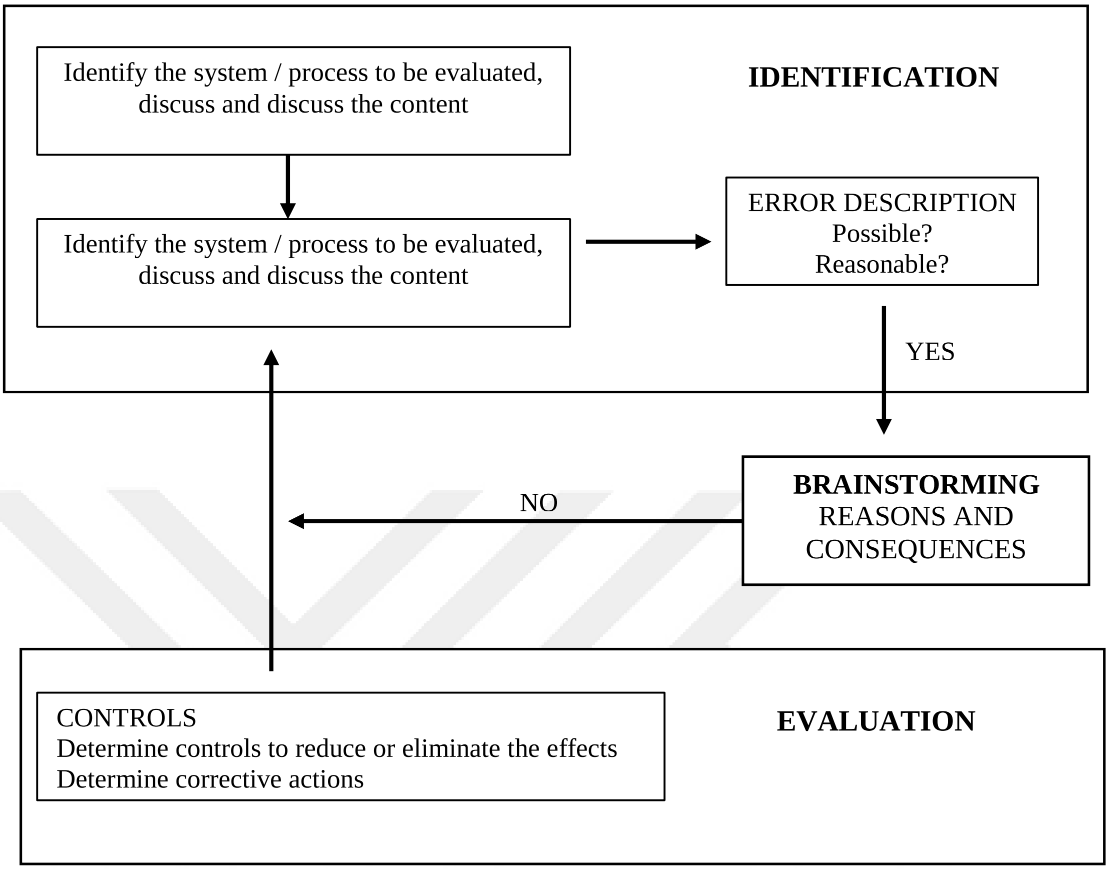

Figure 2.4. Hazard Identification Methods Application Scheme.

- **Change Analysis:** Compare the properties of the modified system with basic known system. Also, this method is applicable in evaluating modifications to operating procedures.
- **Failure Modes, Effects and Critically Analysis (FMECA or FMEA):** This is one of the using way for system reliability analysis and it is the first guideline that was issued in 1949. The aim of this methods is to identify all potential failure modes in components of system, causes of these failure modes and measure the consequences that each failure mode on the entire system.
- **Hazard and Operability (HAZOP) Study:** HAZOP is used by experts for brainstorming and it identifies deviations and dangerous circumstances in a process. This method is a main component of today's risk assessment for process plants.

- **Structured What-If Technique (SWIFT):** SWIFT is applied by a group of experts in brainstorming session where they answered a set of questions including what-if. In this method, a special checklist including "what-if/checklist" is used.
- **Master Logic Diagram (MLD):** MLD can be used to determine hazards in a complex system, that are faced with various types of hazards and failure modes.

Together with the collection of the necessary data, the second phase of the risk assessment is the identification of the hazards. Hazard Identification or HAZID contains possible causes of events and the determination of potential damage. This technique involves different methods and the following are required for all HAZID methods [22], [23]:

- The method used should be creative and should be done accordingly considering the risks that are not taken into consideration before.
- The method should be of a robust and versatile assessment.
- Lessons should be taken from pre-existing hazards / accidents.
- The aim should be clear and understandable. This will determine which hazards will be taken into consideration and which hazards will not be assessed.
- A team of experts from the different disciplines and the practical experience of the system or the process of operation should be selected.
- The leader of the team must be able to encourage creative ideas.
- Brain storms should be created during team work and results and suggestions should be listed. At this point, the method will operate according to group dynamics rather than individual opinions.

2.4.3. Risk Analysis

With the identification of the hazards, the corresponding frequency and consequence values are emerging. A risk matrix is a tabular illustration that is used for frequency and severity of hazardous events or accident scenarios in order to rank hazardous events according to their importance, and to determine the need for risk reduction for each case [21].

When constructing a risk matrix to be used in a qualitative risk appraisal, the frequency component can be dealt with in two different ways, motion-based and process-based. In ports with a large number of movements, it would be more appropriate to adopt a movement-based scale. With the use of the probability scale, the probability of a danger occurring in a given time frame is revealed. The probability scale of the risk matrix used for port risk assessment is shown in Table 2.2 [6], [21].

Table 2.2. Frequency Classes. . Rausand, Marvin. "How to Measure and Evaluate Risk", Risk Assessment Rausand/Risk Assessment, 2013.

Category	**Frequency (per year)**	**Description**
5. Fairly normal	10 - 1	Occur frequently
4. Occasional	1 - 0.1	Will normally be experienced
3. Possible	10^{-1} - 10^{-3}	Will possibly be experienced
2. Remote	10^{-3} - 10^{-5}	Will not necessarily be experienced
1. Improbable	0 - 10^{-5}	Extremely rare event

The consequences of an accident may be classified into different levels based on their severity. In Table 2.3., an example of such classification is given. When a risk assessment of a particular system is performed, it is often useful to adapt the categories to the situation at hand. Severity categories are generally defined such that the severity of a category is about ten times greater than the severity of the previous category. With this approach, the numbers of violence will be on a logarithmic scale [21].

Table 2.3. Classification of Consequences According to Their Severity. https://www.qut.edu.au

Consequence Types			
Category	**People**	**Environment**	**Property**
5. Catastrophic	A few fatalities	Ecological improvement ≥ 5 years	Total system lost and big damage
4. Severe loss	One fatality	Time for restitution of ecological resources = 2-5 years	Loss of main part of system; production interrupted till months
3. Major damage	Prolonged hospital treatment	Ecological resources cycle ≤ 2 years	Considerable system damage
2. Damage	Medical treatment and lost-time injury	Local environmental damage of short duration (≤ 1 month)	Minor system dam- age; minor production influence
1. Minor damage	Minor injury, annoyance, disturbance	Minor environmental damage	Minor property dam- age

The measurement of consequences in maritime sector can be analyzed under four different categories which are human loss and injury, loss of property, environmental impact and loss of work at port. All categories used for the impact criterion should be handled one by one, as if each provides a measure of the consequences of different types of losses. In this respect, if a risk scale shows a high level of risk, it is possible to arrive at the need for risk control in that region [21].

The risk assessment process is a result of a risk matrix. The risk matrix includes summary information that constitutes the input of the identified risks, probability and impact criteria, and risk mitigation and monitoring activities [21].

An approach which is obtained from risk matrix is “As Low As Reasonably Practicable” or ALARP in order to determine whether or not the risk related to system or an activity is acceptable. ALARP has two components which are listed below [21].

- Providing framework for analyzing the risk which requires a clear description and analysis of the risk tolerance.
- Involving a method for determining if a risk mitigation measure is disproportionate to the benefits it will provide, and therefore if the measure is to be implemented.

ALARP describes risk in three categories (Fig 2.6.). These are determined below.

- **Unacceptable Region:** It is where risks are intolerable expect in extraordinary conditions, and risk reduction measures are mandatory.
- **Middle Band (ALARP Region):** It is where risk reduction measures are desirable but may not be performed whether if the cost is grossly disproportionate to the benefit obtained.
- **Broadly Acceptable Region:** It is where no further risk reduction measures are needed. In this region, further risk reduction is not economical and resources can be better spent elsewhere to reduce total risk.

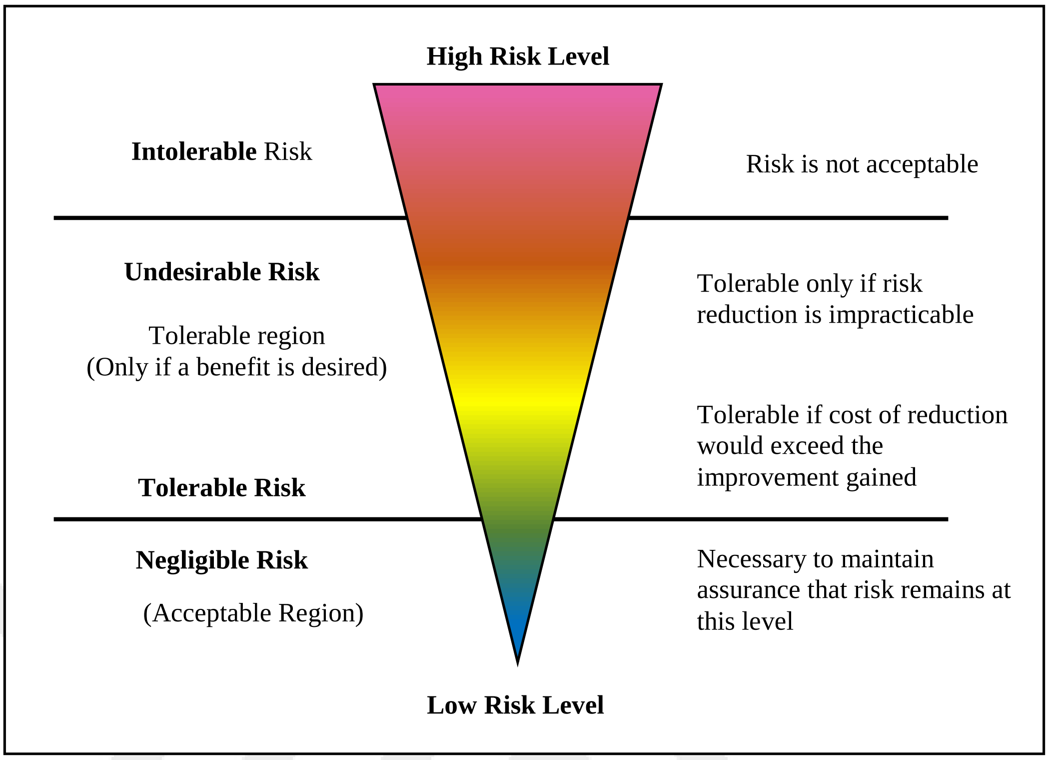

Figure 2.5. The ALARP Principle (adapted from IMO).
https://www.nebosh.org.uk

The risk that is in ALARP region should be reduced to an ALARP level. In order to determine the reasonable practicable, the followings should be considered [21].

- The severity of the hazardous event in question.
- The get information for cases and giving advise avode to effects.
- The evulate to usablity of advise.

2.4.4. Determination of Risk Management Strategy

Risk ratings should be established and control of the safety risks leading to the damage and pro-active (preventive measures) approach should be taken to reduce the effects of such risks. The information gained during the identification of hazards will shed light on this issue and get necessary steps to avoiding such risks will be set in this direction. The order of the measures to be taken or the priority of that risk is directly proportional to the risk score [23].

Risk scores can be defined with a value between 0 to 10 points. Based on this scoring priority order can be determined. In order to reduce or eliminate the risk factors through brainstorming, the priority risks should be considered as first step. Risk scores and their meanings are listed in Table 2.4. [23].

Table 2.4. Risk Scores and Their Explanation. docplayer.net

Risk Score	Explanation
0-1	Negligible risk
2-3	Low risk
4-5	ALARP
6	Heightened risk
7-8	Significant risk
9-10	High Risk

As a result, together with this and similar risk control practices, based on the defined risks, it is possible to introduce different and holistic risk management strategy.

2.5. Maritime Risks

Maritime activities have important role in trading, business and economy of many countries. Marine activities including overseas and local transport, fishing, marine platforms and fish farming. These activities pose a risk to the environment [19].

In the maritime sector, the concept of risk is related to the frequency and consequences of accidents. The accidents may lead serious environmental pollution, harm to human beings as injuries and fatalities, or economic losses as damage or loss of vessel and cargo, lost income. This leads to increasing environmental concerns for the maritime environment and a more careful examination of the potential environmental impact assessment for the maritime development plan. In such cases, the resulting situation as a result of the accident would be perceived not as loss of life but as damage to the environment and loss of income measurements. In maritime sector, typical accident types are listed in Table 2.5. [6], [20].

Table 2.5. Maritime Accident Types. Seung-Gi Gug, Gen Fukuda, A-Ra Cho, Hye-Ri Park. "Collision Risk Analysis in Busan Harbour", Journal of Navigation and Port Research, 2014

Type	Comments
Collision	Contact with other vessel or sea vehicle
Contact/impact	Striking with objects
Grounding and stranding	Vessel making contact with seabed or underwater obstruction
Foundering and flooding	Opening of hull
Hull and machinery failure	Without Control Vessel
Fire and explosion	Potential for injury to persons and loss of goods
Missing	
Other miscellaneous	

2.5.1. Maritime Risk Estimation

In maritime, risk estimates are made forwards and backwards. Backward estimates are based on the number of accidents that occur in a given situation. In this way, there would be a confidence that the risk is correctly estimated. The forward estimates are made when the backward estimates cannot be made due to a small number of actual winnings. These include possibilities based on event analysis linked to the chain of events. The likelihood of each of these events is obtained by comparing the data received from other states. If this information is reliable, the final risk estimates will depend on the comparability of the cases and whether the series of events are correctly identified [6].

2.5.2. Maritime Risk Reduction Approaches

Maritime risk reduction approaches can be examined under 5 basic headings.

- Vessel Traffic Services (VTS)
- Working limitations
- Working rules
- Navigational aids
- Traffic Separation Scheme (TSS)

2.5.2.1. Vessel Traffic Services (VTS)

Vessel Traffic Services (VTS) are interested in managing ship traffic on marine routes and suggest the appropriate route for vessels in order to prevent collisions and accidents. Through VTS, safety of navigation, human life, assets and marine environment is ensured by managing the safeness of vessel traffic within the sea borders. Thus, applying these regulations properly should be obligated for all vessels entering or leaving or navigating inside maritime straits [24]. Vessel traffic services involve radar system, Automatic Identification System (AIS) and radio direction finder. Radar system contains transmission of marine information through radio waves in certain frequencies. Thus, reading these frequencies could be useful to determine size and speed on any incoming vessel in a distance of several miles. AIS provides a broadcast system which helps in recent data of related vessels automatically. As it is understood from its name radio direction finder is useful tool to locate direction of a vessel [24].

2.5.2.2. Working Limitations

Working limits concern sea risk and safety. Criteria that determine the level of risk and safety, the working limits should also be determined. When boundaries are determined, they can be checked whether they are crossed or not. These limits are determined for tugboat, mooring operation, guiding, fender resting speeds, reverse maneuvers, berth movement on berths. It is also an important ground for tugboat operations, emergency scenarios, quay operations and waiting times [6].

2.5.2.3. Working Rules

Working limitations naturally provide for the formation of working rules. These rules may include, for example, what safety items may be for certain vessels in certain regions, what to do in an emergency, and so on. Issues. Additional information provided by ship masters and terminal operators may also contribute to local codes of conduct on terminal operations and safety requirements [6].

2.5.2.4. Navigational Aids

Navigational aids have vital importance in reducing risks at marine. There are differences in type, size and shape of navigation aids depending on the region and purpose of installation. These are buoys, lanterns and lantern ships, transit lines, fog signals and radar reflectors, etc [6].

2.5.2.5. Traffic Separation Scheme (TSS)

Traffic Separation Scheme (TSS) is a traffic management system that regulates traffic in certain areas and makes vessels take either the upstream or the downstream route. TSS allows the ships to navigate their routes in such a way that they are unaffected by each other. This reduces the risk of conflict and collisions. TSS can also create coastal traffic areas in small craft that do not use main traffic lines. [25].

3. FERRY TRANSPORTATION IN WORLDWIDE

3.1. Marine Transportation: A Brief Introduction

From one area to another, transporting of goods and passengers by sea is called as marine (or maritime) transportation [26]. Marine transportation includes trade and service area, is an industry by itself, especially in terms of cargo and passenger transportation, port services and sea tourism [27]. Ports and vessels are two important factors for maritime transportation. Ports are the points where maritime transport starts and ends. Marine transport is the most economical, least costly type of transport compared to other types of transport, based on a survey conducted by the International Civil Aviation Organization [28]. Thus, with the help of cheap transportation, it will provide the preservation and continuity of the transportation, the markets and the passenger transports also generate the social benefit. Marine transportation is most likely preferred due to the facts that being more economic for carrying maximum load at one time, reliability, having no borders overrun, causing minimum level of property damages and being less expensive than air, highway and railway transportations [11], [27].

Today, marine transportation contains a huge part of all trading in the world. The world economic growth was found to be mainly depended on seaborne trade so; this state makes maritime transport becoming the backbone of globalization for international trade. The world fleet grew by 3,5% in terms of dead-weight tons (DWT) between the first day of 2015 to 1st of January, 2016. Based on United Nations Conference on Trade and Development (UNCTAD) 2016 Report, in 2015 estimated world seaborne trade volumes exceeded 10 billion tons for the first time (Table 3.1.). Shipment expanded by 2.1%, which is found to be slower than previous years [3]. In terms of marine transportation in Turkey, freight tonnage in Turkey's ports in 2015 was increased by 8.6% compared to the previous year. Around 416 million tons of freight were transported by sea in 2015 in Turkey by 2015, and the amount of freight handled in Turkish ports was increased by 33 tons to 8.6% compared to previous years [3], [29]. In a worldwide horizon, Turkey is in 15th place in terms of dead-weight of tonnage of ownership of world fleet according to UNCTAD report, 2016 [3].

In terms of marine transportation in Turkey, freight tonnage in Turkey's ports in 2015 was increased by 8.6% compared to the previous year. Around 416 million tons of freight were transported by sea in 2015 in Turkey by 2015, and the amount of freight handled in Turkish ports was increased by 33 tons to 8.6% compared to previous years [3], [29]. In a worldwide horizon, Turkey is in 15th place in terms of dead-weight of tonnage of ownership of world fleet according to UNCTAD report, 2016 [3].

Table 3.1. Developments in International Seaborne Trade, within 1970 – 2015. https://www.pepperdine.edu

Selected Year	Total (all cargo)[a]
1970	2,065
1980	3,074
1990	4,008
2000	5,984
2005	7,109
2006	7,7
2007	8,034
2008	8,229
2009	7,858
2010	8,409
2011	8,785
2012	9,197
2013	9,514
2014	9,843
2015	10,047

(Millions of tons loaded)

[a]Total cargo includes; oil and gas, main bulks (iron ore, grain, coal, bauxite/alumina, phosphate rock.) and other dry cargo.

Marine transportation is not a only one type of transportation that is taken advantage only by seaports and proper stream facilities. With the availability of using more than one transportation way together, cargos can be carried easily to city or countries which are far away from the sea. This system has opened the way of development of highway, railway and airway; and resulted in usage of combined ways of these roads in order to transmit cargos to interior areas. Especially in developed countries, these type of combined transportation systems dominates the whole transportation system [30].

In addition to its important place in trading, marine transportation also facilitates transporting of passengers from one point to another. Especially after 1800’s, there was a huge demand for travelling between Europe and the colonies in the East and the West and leaving of emigrants for North America. Based on this type of transportations, there are two classifications: for long-distance usage such as cruises and for short-distance usage such as ferries [31]. Based on UNCTAD report published in 2016, 59% of world's ships are cargo-carying ships and about 34% of cargo-carriers are dry-cargo or passenger ships which can be either a passenger ferry that services across a narrow strait or large and long-side vessels that carry merchant trade [3].

Among these categories, passenger vessels contain cruises and ferry passenger vessels. While, cruise vessels provide pleasure voyages between different coasts and ports, ferry vessels specialize in carrying passengers and their autos and trucks between rivers, short distances, ports or islands. Those transporting passengers and their vehicles are called as roll-on roll-of ferries, due to the ferry's property of having large holes that allowing for loading (roll-on) and unloading (roll-off) of vehicles [32]. Today, however, there are ferryboats carrying passengers or vehicles between two ports at long distances [26], [31]. In many cases, ferries are the only transportation form which is available because of the geographic condition in specific places such as Isle of Wight an English island since there is no other possible transportation to that island (Fig. 3.1.) [33], [34].

Figure 3.1. A map showing routes and destinations between England and Isle of Wight
https://www.wightlink.co.uk/go/isle-of-wight-ferry-routes-destinations

3.2. Historical Background of Ferry Transportation

In the beginning of 19th century, London had been known as center of maritime; and at these days, even in London, cars and other vehicles were passed to other side of Thames River with primitive boats which were continuing through two lines of stretched chains (Fig 3.2.).

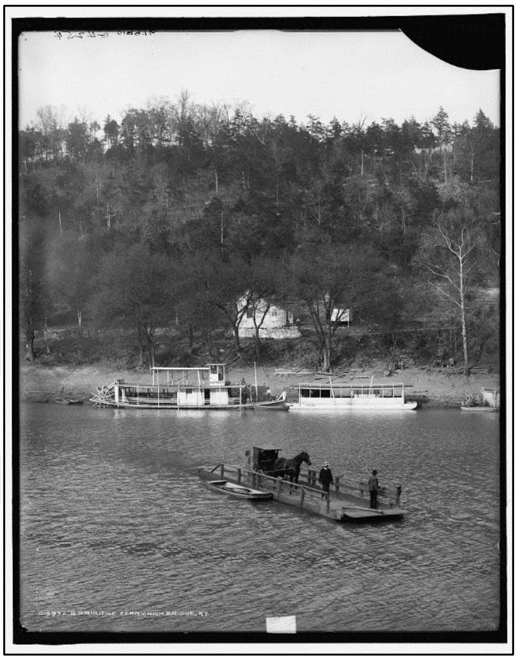

Figure 3.2. A Photo of Primitive Ferry in High Bridge, Ky. At 1907
(Detroit Publishing Co. no. 019976; http://loc.gov/pictures/resource/det.4a13851)

At the same time the first long-side-sea ferry trials were powered by eight horses in America in 19th century called the *Experiment*, however it was not a successful attempt (Fig 3.3.). Yet, it was impractical and with the development of steam engines and thereby sea transportation, ferries have been developed into much beneficial transportation vehicles. [35].

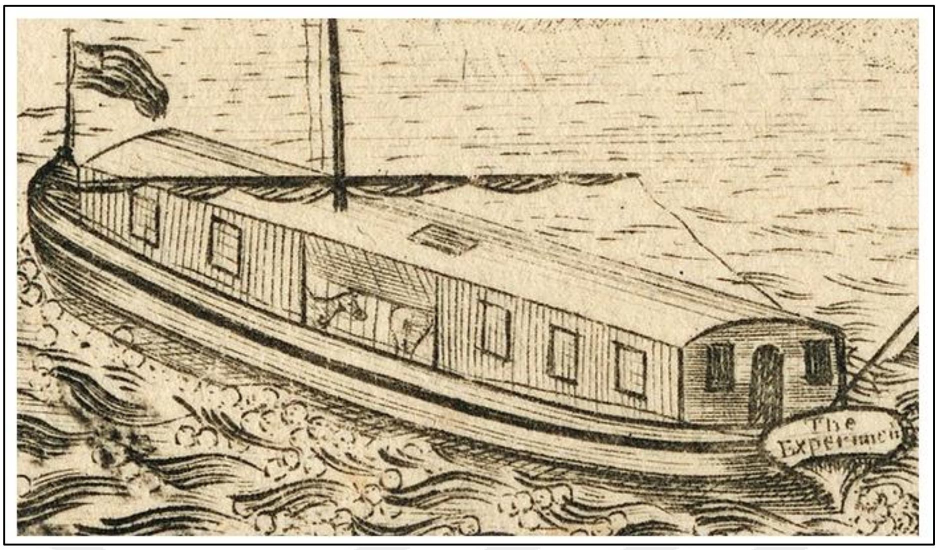

Figure 3.3. A Painting of Boat “The Experiment”.

Ferries of Tersane-i Amire for passengers had been using since 1840 in Ottoman Empire. The first ferry transporting cars and passengers, “Suhulet” was designed by a Turkish Hüseyin Haki Efendi who worked as head manager in Şirket-i Hayriye, the first incorporated company of Ottoman Empire (Fig 3.4.). The ferry was able to travel at 450 horsepower and 7 miles an per hour. This development opened the way for producing various kinds of ferries all over the world [36].

After the first boat, Hüseyin Haki Efendi ordered for another boat which differs from the first one with double machine instead of one like in the first boat. The second boat was named as “*Sahilbent*” which means connecting two sides [36]. These two boats served for a long time that the first one was sold in 1961 after working 89 years, and the second one was sold in 1959 after working about 80 years. The second boat passed into other hands several times and, 125 years later after its construction, in 1996 it was continued to serve. On the other hand, Suhulet, 136 years after its construction, in 2007, has started its services again, after renew period by Turkish engineers. Suhulet and Sahilbent was two of the most important achievements of Turkish Maritime history, and created with the efforts of Hüseyin Haki Efendi [36].

Figure 3.4. (a) Hüseyin Haki Efendi, (b) The First Car-Ferry “Suhulet”. E. Tutel, “İlk araba vapuru bir Türk’ün buluşu”, *Popüler Tarih - Dünya Yayınevi*, Türkiye, ss. 52–55, 2001.

Since that time, many ferries have been constructed and carried passengers from coast to coast of seas. Today, across the world there are 6210 routes, 2490 ports, 720 operators and 2560 ferries present. It is used as a mean of transportation and also as a mean of travel with numerous lines all around the world. Based on a news in Mail Online, the ten best ferry journeys which are preferred by many are with Alaska Marine Highway System in USA, Ilala Ferry in Lake Malawi, Star Ferry in Hong Kong, Oban Bay to South Uist Scotland, Manly Ferry in Sydney, The Golden Horn Ferry in İstanbul, Golden Gate Ferry in San Francisco, Monte Carl Harbour in Monaco, Dalmatian Coast Croatia and Staten Island Ferry New York (Fig 3.5.) [37].

Figure 3.5. Local Transport with Alaska Marine Highway System. S. Gordon, “The ten best ferry journeys in the world”, *Mail Online*, ss. 1–14, 02-May-2010.

As a result of modernization remarks and environmental pollution concerns, Siemens co-associated with Fjellstrand (a Norwegian shipyard) and developed a unique technology for the world’s first electricity-powered car ferry (Fig 3.6.) [38].

Figure 3.6. The First Electric Car and Passenger Ferry in The World, Norway. http://www.maritime-executive.com/article/worlds-first-electrical-car-ferry-in-operation.

The ferry provides no carbon dioxide emissions and is very popular in Norway car and passenger marine transportation. This environmentally friendly ferry contains electric propulsion system having lithium-ion batteries which are charged from hydro power through charging stations (Fig 3.7.). The ferry only uses 150 kWh per route, which corresponds to three days use of electricity in a standard Norwegian household. The fully electric ferry travels six kilometers across the fjord (inlet) 34 times a day, with each trip taking around 20 minutes [38], [39].

Figure 3.7. Charging Stations at Ports, Norway. http://www.maritime-executive.com

The main reason why more attention is paid to ferryboats is that the stitching of transport systems in many coastal areas has forced them. To lower the air emission due to congestion and to decrease the financial costs, hydrogen fuel cell powered ferries named Hydrogenesis and MF Ole Bull were operated by Bristol Green Capital initiatives in United Kingdom and by CMR Prototech in Norway, respectively [40], [41].

Many projects have been working on to modernize the passenger carrier ship – ferries to lower the cost and air emission as well as to decrease the congestions and high-risk accidents.

3.3. Ferry Transportation in Worldwide

Ferry vessels are one of the most popular transportation type in the world especially it’s is preferred and only one way of transport when there is no connection between two places. Ferry transportation is extremely preferred and widespread in European countries especially in Northern Europe, the Baltic and the Mediterranean. Due to European’s elongated coastlines (more than 68.000 kilometers in length) and islands (more than 5.000), ferry vessels have a big role in transportation. Through ferry transportation two islands can be linked and connected to each other and thus preventing isolation and offering equal growth opportunities to smaller islands and improving tourism can be achieved [42].

Based on Eurostat Statistics, with more than 70 million and 60 million respectively in Italian and Greek ports took care of more than 34% of total number of passengers inwards and outwards in European (EU) ports in 2015 (Table 3.2.) [43]. The table includes total number of seaborne passengers in 2014 and for 2015 data total number of passengers were separated in terms of both cruise and non-cruise passengers (ferry users). It is clearly understood that, passengers using ferry transportation is much more than cruise passengers since ferry transportation is mainly used for transferring from one place to another as a necessity. Italy and Greece remained the main countries by means of EU seaborne passenger transport. These countries are followed by Denmark with 40 million passengers in 2015 which was increased slightly as 0.7% by compared to 2014. The largest increases in marine passenger transport were recorded in Bulgaria (+60.1%) **(Table 3.2.).**

Table 3.2. Seaborne Transport of Passengers Inward and Outward in All Ports between 2014 And 2015. http://ec.europa.eu/eurostat/web/main/home.

	2014	2015		
	Total	Non cruise	Total	Growth rate 2014-2015 (%)
EU-28	**392890**	**205916**	**395367**	**+0.6**
Belgium	821	353	844	+2.8
Bulgaria	1	2	2	+60.1
Denmark	41353	41280	41647	+0.7
Germany	30780	28862	30087	-2.2
Estonia	13654	14153	14164	+3.7
Ireland	2755	2750	2751	-0.2
Greece	66340	65295	65680	-1.0
Spain (1)	23486	22422	25013	+6.5
France (2)	26638	25203	26133	-1.9
Croatia	23523	27220	27271	+15.9
Italy	72225	66129	70268	-2.7
Cyprus	76	1	68	-11.0
Latvia	802	602	602	-25.0
Lithuania	280	286	286	+1.9
Malta (3)	9669	9479	9479	-2.0
Netherlands	1819	1910	1910	+5.0
Poland	2224	2421	2421	+8.9
Portugal	551	536	583	+5.8
Romania	1	0	1	+15.8
Slovenia	27	34	34	+25.7
Finland	18487	18817	18817	+1.8
Sweden	29244	29357	29500	+0.9
United Kingdom	28135	25854	27805	-1.2
Iceland	723	737	737	+1.9
Norway (4)	7908	7231	7311	-7.5
Montenegro	108	99	99	-8.2
Turkey	2150	1706	2233	+3.8

(1) 2015: provisional estimates.
(2) Partially estimated by Eurostat.
(3) International passenger transport to/from Valletta not included.
(4) Data on international maritime passenger transport only.

Many decrease in the number of seaborne passengers are caused by structural changes, such as building new bridges or tunnel connections or closure of ferry links.

The majority of the seaborne transportation in the EU is carried out between ports in the same country, revealing the dominant role of national ferry services in the EU seaborne passenger transport. Mostly, countries with busy ferry connections within well-populated islands have large volume of ferry transportation. Thus, Italy and Greece having large number of islands are the leaders in seaborne passenger transportation as well as Spain, Croatia and Portugal [42], [44].

Based on Eurostat Statistics, the top 20 passenger ports were clarified for 2015. The port of Dover in the United Kingdom (UK) maintained its position as being the largest EU passenger port, despite a 2.2 % decrease in the number of passengers inward and outward from 2014 to 2015. The Spanish port of Palma de Mallorca was recorded the largest relative increases in the number of passengers between 2014 and 2015 (+14.4 %), while the Italian ports of Capri and Napoli recorded the largest decreases in the same period (-28.1 % and -15.3 %, respectively) (Table 3.3.) [43].

Table 3.3. Top 20 Passenger Ports in 2015 - On the Basis of Number of Passengers Embarked and Disembarked. http://ec.europa.eu/eurostat/web/main/home.

Rank 2015	Port	Sea	2014	2015	Growth rate 2014-2015 (%)
1	Dover (GB)	Atlantic	13381	13082	-2.2
2	Helsinki (FI)	Baltic	10942	11214	+2.5
3	Stockholm (SE)	Baltic	9933	9887	-0.5
4	Calais (FR)	Atlantic	10703	9757	-8.8
5	Tallinn (EE)	Baltic	9098	9299	+2.2
6	Piraeus (GR)	Mediter.	8136	8169	+0.4
7	Helsingborg (SE)	Baltic	7656	7670	+0.2
8	Helsingborg (Elsinore) (DK)	Baltic	7634	7644	+0.1
9	Paloukia Salaminas (GR)	Mediter.	7016	7050	+0.5
10	Perama (GR)	Mediter.	7016	7050	+0.5
11	Messina (IT)	Mediter.	6988	7021	+0.5
12	Napoli (IT)	Mediter.	7652	6484	-15.3
13	Puttgarden (DE)	Baltic	6002	6141	+2.3
14	Rodby (Faergehavn) (DK)	Baltic	6003	6139	+2.3
15	Reggip Di Calabria (IT)	Mediter.	6187	6053	-2.2
16	Palma de Mallorca (ES)	Mediter.	4939	5652	+14.4
17	Algeciras (ES)	Mediter.	5386	5527	+2.6
18	Cirkewwa (MT)	Mediter.	4643	4740	+2.1
19	Mgarr - Gozo (MT)	Mediter.	4643	4740	+2.1
20	Capri (IT)	Mediter.	6054	4355	-28.1

Ferries play a crucial role in transportation of people and goods and European countries have the largest ferry transportation services. In general, ferry transportation is highly fuel-efficient and sometimes it is the only transport system between two ports. So, due to ferries' rapid growth in the seaborne traffic and being mostly preferred mode of transport cause an increased in energy consumption and a source of carbon air-polluting emission. That's why many developed countries have been trying to find out *greener* solutions by means of reducing energy consumption, minimizing carbon dioxide emission and decreasing petroleum consumption [42], [44], [45]. These various environmental concerns were discussed by the EU and the Member States in the International Maritime

Organisation (IMO) and as a result various restricted policy related with emission from ferries have been applied since then. Based on these policies and environmental concerns, green solutions were revealed and ferries with cost effectiveness, emission control area friendly vessels have been made by several ferry operators (Table 3.4.) [42]. Table 3.4. shows main European ferry operators that shows new technology green ferries and many of them are found in Norway.

World's first electrical car and passenger ferry is powered by batteries and made by Siemens and Fjellstrand co-op in Norway. The ferry is 20 meters wide and eighty meters long, able to transport up to 120 cars and 360 passengers and works with 260-kWh unit supplied electricity. The fully electric ferry travels the fjord 34 times a day, with each trip taking around 20 minutes. Through this re-charged battery technology, zero-emission ferries are freely used by Norway. This was an innovative approach and other companies were followed it (Fig 3.8.) [38], [39].

Figure 3.8. The First Electric Car and Passenger Ferry in The World in Norway.
http://www.maritime-executive.com/article/worlds-first-electrical-car-ferry-in-operation.

Siemens also worked with Norled ferry operator to build up an electric ferry, changing the battery thus reducing the cost of fuel by up to 60%. This was achieved by adding three battery packs. The Norled ferry uses about two million kWh per year, whereas a traditional diesel ferry consumes at least one million liters of diesel a year and emits 570 tons of carbon dioxide and 15 metric tons of nitrogen oxides which are high values and cause environmental pollution [39], [46].

Reducing carbon emission is also concerned by CMR Prototech, Norwegian engineering. Hydrogen fuel cells were installed on Osteroy car ferry MF Ole Bull, which is the first car ferry in Norway with hydrogen cells as well as United Kingdom's (UK) first hydrogen powered ferry, Hydrogenesis, working in Bristol harbor cause zero emission and environmentally-friendly conditions [40], [41].

There are many eco-friendly ferries are used in European countries with fully-electric performance and hybrid technologies that providing low-cost, high-speed (thus increased departure frequency), dependability, safety, comfort and environmental quality [42].

Although most maritime air pollution is brought by shipping traffic, passenger and car ferries have a big role in carbon-air polluting emission. Thus, Environmental Protection Agency (EPA) got some protections based on this pollution issue. Many developed countries are applying these rules like United States (US). In US, increasing demand for regional mobility due to rising road congestion motivated passengers to use ferry transportation, thus leading to ferry expansion and modernization plans in many parts of the US [47]. There are many coastal urban regions, rivers, lakes, islands are found in US and transportation is done by ferry systems and the state of Washington manages the largest passenger ferry vessel. In California, San Francisco Bay Renewable Energy Electric Vessel with Zero Emissions (SF-BREEZE) ferry vessel project was managed. With this, US also provides zero emission ferry systems to its high seas. The project involved a design of a ferry with high-speed performance and fuel cell powered, and a hydrogen refueling station (Figure 3.9.) [41], [46].

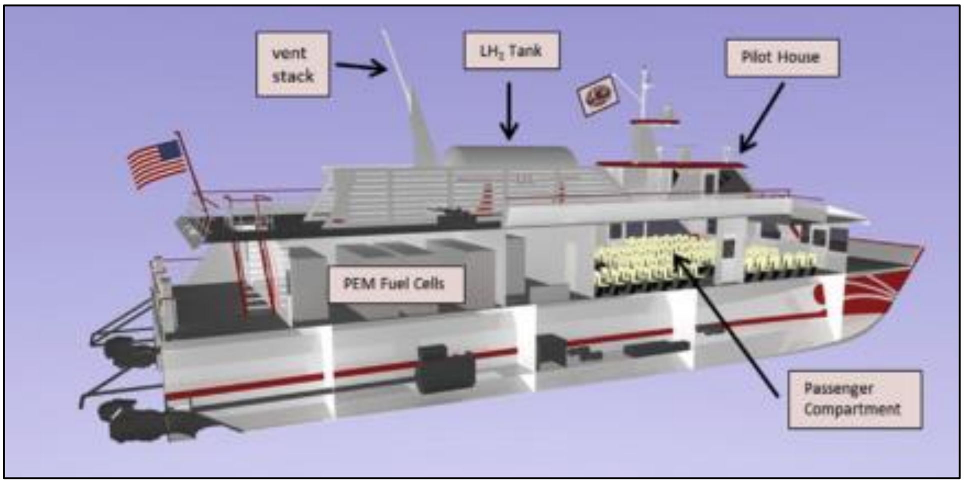

Figure 3.9. Engineering Model of SF-BREEZE. https://energy.sandia.gov

In developing countries, ferry vessels are not just for transportation, it also provides and maintain unity in nations through allowing access to distant and/or isolated islands and locations. Although many regulations are run in the world, many problems and accidents due to not applying these rules are happened in developing countries [7].

Finally, ferry vessels have been using all over the world. In developed countries, ferries are evaluated as the safest for of marine transportation besides, ferry developments are progressed for better environmental conditions and reduce air and sea pollution. In developing countries, domestic ferry lines have been a major transport type for national economic activities and also ferries connect islands and isolated locations to provide access to common activities and places, thus maintains national unity.

3.4. Ferry Transportation in Turkey

Turkey has an important role in marine transportation especially because of its geographical conditions that connects Black Sea and Mediterranean Sea through Dardanelles, Sea of Marmara and Bosporus. Depending on international conventions and regulations, Turkey prepared its own legislation to prevent marine pollution caused by seaborne traffic. These regulations involved, Turkish Ports Code 618 in 1935, Coast Guard Command Law in 1982, Turkish Environmental Code 2872 in 1983, Water Pollution Control Regulation in 1991 and the Waste Reception Services Regulation dated in 2004 [28].

Besides its role in marine trade, there are many ferries providing both national and international travel and transportation [28]. The İstanbul strait ferry in Istanbul is one of the best ferry ride for travel, which works between European and Asian sides of Istanbul, Sea of Marmara (Fig 3.10.) [37].

Figure 3.10. İstanbul strait ferry ”ŞHT. ERGUVAN”, Istanbul, Turkey.

Ferry transportation is very common in Turkish straits. There are passenger and car ferries connects Asian and European part of Marmara Region and ferries work between different cities located in seaside which are time-saving and provide transportation in a short time without suffering from highway traffic. Moreover, ferry transportation in Turkey work to connect islands near Turkish straights and provide travel to Lebanon, Italy, Greece, Greek islands (Fig 3.11.) [6], [48], [49].

Figure 3.11. Ferry lines between Turkey and near country. https://aegeantourtravel.com

4. OVERVIEW ON FERRY ACCIDENTS

4.1. Basic Causes of Ferry Accidents

Marine transportation is considered as a safe way of transportation. Even it is safer than air transportation and comparable to railway transportation, maritime accidents are happening due to several reasons and the consequences are unfavorable because of the presence of passengers, the value of cargo carried and pollution risk [25], [47], [50].

Ferries offer a crucial role in transportation people and cargo for many developed and developing countries, especially in island arc, archipelagic states like Indonesia, Fiji, Bahamas, Philippines and in river delta states such as Mississippi and Bangladesh. In spite of this obtainment, the dependence on ferries results with a high rate of accidents and fatalities in many countries, especially in developed countries. Many reasons are found but accidents mainly linked to using of old, substandard, and/or inappropriate ferries in low-income nations; overcrowding; insufficient training; human errors; and sudden risky weather [51].

4.1.1. The Effects of Human Error

Marine industry has been evolved over the last 50 years. During this period, marine industry showed serious fundamental changes and based on that the main concerns are improving the ship structure and increase the reliability of ship systems to reduce possible accidents and increase efficiency and productivity. Today's ship systems provide much more advanced technology and are mostly reliable and safe [18], [52].

Human error can be described by three main subjects and these are, an incorrect decision, an inappropriately performed action and/or improper lack of action. In ferry system includes ship's crew, operators and others. The performance of these people, their training levels, their abilities and limitations as well as their motivation may affect the faith of ferry transportation in incidents [53]. Marine system is human-dependent system and human errors are related with technology, organizational factors and environmental system. Technology has a big influence on how people react and perform to an action so that, a person's performance on how to use the ship system is directly connected to how the technology is represented on that equipment. For this reason, the clear and reliable design and technology of ferry is important when it is needed in unwell conditions [54]. The environmental conditions also affect performance. Those environmental conditions can be weather conditions, physical working conditions such as lightning, noise, temperature, regulatory and economic climates. Lastly, organizational factors like crew, staff organization and shipping company policies influence human performance. Training and number of crew directly affect workload and thus performance. Irresponsible attitudes and miscommunications between crew members might be a big cause of accidents. Besides, members should work under proper schedules and have motivation to overcome hard conditions [52], [54]. Marine systems are people dependent thus, human errors are prominently expected in many casual situations. About 75-96% of marine casualties are caused, at least in part, by some form of human error. Researches have shown 84-88% of tanker accidents, 70% of towing vessel groundings, 89-96% of collisions, 75% of allisions and 75% of fires and explosions are caused by human [54].

Based on U.S. Coast Guard findings, human problems are being fatigue, incapable communication and coordination between pilot and other crew members, and impractical technical knowledge especially for radar readings. Being fatigue is the main concern and most frequently happening problem of marine crew members. 16% of the vessel casualties and 33% of member injuries were a result of tired members. Another cause is incapable communication between pilot and other members or ship-to-ship. 70% of collisions and allisions are as a result of inadequate communications. Also, inadequate general technical knowledge and knowledge of own ship systems contributes to accidents. These problems can be solved with better training of employees, standardized equipment design and maintenance of the current method of assigning crew to ships [32], [51], [54], [55].

Based on Golden and Weisbrod research, 80% of maritime vessel accidents are caused by human errors. They put 14-year dataset between the years of 2000 and 2014 to reveal the role of human error across more than 200 ferry accidents happened in the world. There was only one concern about this study on defining human error which was written of non-reliable reports about accidents by the personnel who didn’t have an access to the scene of the accidents. This was solved by running two types of analysis which were conservative parameters and liberal parameters. Under conservative parameters, human errors were considered as the errors having direct relation with the accidents. These can be overloading of passengers, unbalanced rolling cargo and collisions with other ships. Under liberal parameters, human errors definition was broadened. Misjudgment of weather conditions, insufficient fixing of the vessel can be counted under liberal parameters. Based on these specifications, 53% of all accidents were caused by human error under conservative parameters, and this value is 74% under liberal parameters. In addition to this, when accidents having incomplete accidental report were removed, the values became 62% for conservative measure and 86% for liberal measures, respectively. The dataset included 21,574 fatalities, 70% were found to be related with human errors under conservative parameters and this value is 86% for liberal parameters. When the accidents with incomplete accidental report was excluded the percentage for fatalities became 75% and 92% of fatalities caused by human errors based on conservative and liberal measures, respectively (Table 4.1.) [51].

Table 4.1. Summary of Results of Human Error Ferry Accident Analysis. https://scholarcommons.usf.edu

Number of Accidents	**Conservative**	**Liberal**
% HE[1] by total known cases	62	86
% HE by total known cases, known and unknown	53	74
% unknown	14	14
Fatalities (dead and missing)		
# fatalities caused by HE	15.156	18.595
% fatalities caused by HE by total known cases	75	92
% fatalities caused by HE by total known cases, known and unknown	70	86

[1]HE: Human Error

Human errors are generally happened as a result of technological, environmental, and organizational problems and deficiencies. To overcome these issues, managements have been trying to persuade or threaten the working members to do their job better and with more attention. However, these approaches cannot be enough in many circumstances. Thus, proper motivational methods or adapting the system to the human himself can be better ways to accomplish decreased number of accidents caused by human errors [54], [56], [57].

4.1.2. The Effects of Weather Conditions

Weather conditions are major factors on ferry accidents like in many maritime accidents. Hazardous weather such as high winds, typhoons, fogs, high and rouge waves in rough seas cause fatalities and vessel loss. Between the years of 2000 and 2014, of the 232 accidents, 50% were partially related with bad weather and unsafe wave conditions as well as monsoon-related flooding and swift currents [51], [58], [59].

Dangerous weather conditions are an important cause of loss of life and property at sea. Heavy sea conditions and waves are important threats for ships. Several ferry cases have been related with unexpected winds/rough sea, as have the loss different kind of ship include navy, fishing, capsize vessels.

Threats caused by weather events at sea are the following

- Typhoons
- Fog and low visibility
- High waves/sea state
- Swift currents
- Rogue waves

4.1.3. The Effects of Overcrowding and Overloading

Overcrowding and overloading problems are caused by many ferry operators (Fig 4.1.). Ticket prices are low and many operators overload ferries with passengers and cargo to earn more money. Ferry vessels have capacity limits, but more passengers and cargo mean more profit. Besides, those operators don’t tend to record the names of extra passengers and when an accident happens because of overcrowding, it is difficult to report total number of dead and missing and reveal person’s identity who is lost. This problem is mainly a big concern in developing countries. Based on Golden and Weisbrod research, 29% of ferry accidents between 2000 and 2014 are caused by overcrowding and overloading [51].

(Photo: AFP)

Figure 4.1. A Photo of an Overcrowded Ferry in Dhaka, Bangladesh.
https://scholarcommons.usf.edu

Mostly ferry owners, constrained by artificially low ticket prices imposed by government regulation, deliberately overload vessels with passengers to get more benefits while reduce their costs. Often, operators do not record the names of passengers who embark after a vessel's capacity has been reached, making it difficult to gauge the total number of dead and missing and to identify individuals who are lost. Overcrowding can precipitate accidents, especially when passengers group themselves on the upper levels of a ferry or rush to one side when they anticipate danger. According the records, overloading the passenger is the main reason engaged a third (29%) of the accidents.

4.1.4. Other Causes

Collision and navigational problems are involved in 22% of all ferry accidents. Moreover, fires and engine trouble especially truck ferry fires are becoming a major concern in worldwide [51].

Other Causes were involved of 22% of all accidents. Recently research find out that truck ferry fires are becoming a most important problem due common ferry vessel design as RO-RO [7]. Of the accidents for which data on the time of day could be collected, 60% occurred during the night or at dawn, when poor visibility and personal fail suffers. On the other hand this result has been involved less than half dataset so it could not be fixed this issue as final decision.

4.2. Ferry Accidents in Worldwide

Ferries have been used many developed and developing countries worldwide as a means of passenger and cargo transportation. Especially for the countries in which there is delta rivers along the country, ferries are important mode of transportation. However, dense usage of ferries brings about accidents when risk factors like weather or location meet with negligence like overloading the ships or rule violations.

In 1987, Dona Paz ferry collided with the oil tanker Vector in Philippines. Result was death of 4,341 people. It is known as the worst maritime disaster.

In 2002, ferry named Le Joola capsized in Gambia, Senegal. There were nearly 2,000 people in the ferry with the capacity of 600 people. The overloaded ferry has been thought to sink in five minutes as a result of the storm. The disaster which causes to death of 1,863 people has been known as the second worst maritime disaster. There was only one woman among 64 people who were able to survive.

In 2006, El Selam Boccaccio 98 ferry sank in Red Sea while navigating from Duba of Saudi Arabia to Safaga of Egypt. There were only 388 people survived from the ferry which carries 1,312 passengers and 96 crew.

In 2008, Princess of the Stars ferry of Philippines capsized at San Fernando. There were 57 people survived from 747 people in the ferry.

In 1993, when Seohae ferry sank with the storm, it was carrying 3 times more passengers than its capacity. In the accident, 292 of all 362 passengers died.

In 1958, Turkey experienced one of the worst ferry accidents of Republic history. Üsküdar ferry cruising between İzmit and Değirmendere sank because of severe wind. 272 people died in the accident.

One of the worst ferry accidents occurred five years ago in South Korea. In April 2014, Sewol ferry navigating from Incheon to Jeju Island sank off Byungpoong Island. In ferry, there were 475 passengers and crew including 325 high school students. The disaster resulted in loss of 304 people, most of those are high school students. Prime President of South Korea of the term Chung Hong-won was resigned. According to the report of Worldwide Ferry Safety Association, from 2000 to 2014 there has been 232 ferry accidents worldwide.

According to the analysis, in 14 years, 21,574 people died as a result of the accidents; 1,541 people for year and 130 lost for per incident. Accidents has taken place in 43 different countries around the world, while three of them (Bangladesh, Indonesia and Philippines) are responsible from nearly 50% of all accidents. Besides, those three countries with Senegal and Tanzania constitutes nearly two thirds of all accidents. Analysis indicated that 94 % of all ferry accidents occurred in developing countries.

That most of ferry accidents has occurred in developing countries results from four main causes according to Roberta Weisboard, executive director of the Worldwide Ferry Safety Association. She explains the factors as, poor quality vessels, overcrowding, sudden hazardous weather and the human factor.

Table 4.2. Ferry accidents with having high death and missing rate between years of 2002 – 2015. https://www.kent.ac.uk

Date	Nation	Developing country (Y/N)	Dead and Missing (Minimum Estimate)	Cause	Overloaded
26-Sep-02	Senegal	Y	1863	Capsized in rough seas caused by storm	Y
3-Feb-06	Egypt	Y	1080	Overloaded, poor vessel condition, fire	Y
29-Dec-06	Indonesia	Y	410	Waves may have washed car deck and gotten trapped there, causing vessel to capsize	N
21-Jun-08	Philippines	Y	814	Although Typhoon Fengshen had already made landfall, the vessel was allowed to sail because it was considered large enough to stay afloat in the typhoon's periphery; however, Fengshen changed trajectory	N
13-Mar-12	Bangladesh	Y	147	Head-on collision with oil tanker	—
18-Jul-12	Tanzania	Y	138	sank in rough seas	Y
16-Aug-13	Philippines	Y	120	Collision with cargo ship owned by Sulpicio Lines	—
28-Sep-13	Nigeria	Y	142	Vessel split in two	Y
16-Apr-14	South Korea	N	312	Capsized because of making a sharp turn	N
4-Aug-14	Bangladesh	Y	172	Tipped over by strong winds	Y
12-Dec-14	Congo, Dem. Rep.	Y	168	Strong winds, overloading	—
22-Feb-15	Bangladesh	Y	100	Hit by cargo trawler Nargis-1	Y
13-Mar-15	Myanmar	Y	231	Weather, overloaded	Y
1-Jun-15	China	Y	442	Capsized in cyclone/tornado or after losing stability on making a sharp turn	N

Y: Yes, N: No.

4.3. Ferry Accidents in Turkey

In Turkey, ferry lines are mainly positioned in Marmara Sea as it is the connection point between Asia and Europe. Correspondingly, Marmara Sea has the higher rate of accidents compared to Çanakkale Sea. Within the Marmara Sea, the most critical and dense area is Ahırkapı Anchor point at south entrance of İstanbul Strait. In this area, risks for accidents has increased with increasing ship traffic. Especially in the case that ships touch each other at anchor point as a result of wind shifts, accidents occurring. Reason for touching is the density of the point. 68 % of all maritime accidents occurred between 2004-2012 took place in this region. In addition, in İstanbul Strait, risks formed through large ships which pass across İstanbul strait to reach Black Sea or Aegean Sea, below-average ships, ships with dangerous cargo and regional expeditionary ships. Efforts to empower cruise safety mainly focus on these transit passing and non-transit passing ships. Risk elements for these ships are determined as regional traffic, oceanographic and topographic pattern. The riskiest case is encounter of regional expeditionary ships and transit passing ships.

In Table 4.3. and Table 4.4. Istanbul strait and Çanakkale strait Accidents Statistics are given. First column represents the years, second represents total accidents, third represents collision and gravel, fourth represents total malfunction, fifth represents malfunction in machine or rudder and last column represents role violation. While accidents highly increase in 2010 at İstanbul Strait, it has decreased to the lowest level in 2014. Yet, there is still high number of malfunctioning take place [60].

Table 4.3. İstanbul strait Accidents Statistics 2004-2014. Altan, T, “Maritime Traffic Analysis of Marmara Sea”, January 2014

YILLAR	KAZA (TOPLAM)	ÇATIŞMA VE KUMA OTURMA	ARIZA (TOPLAM)	MAKİNE VE DÜMEN ARIZASI	TÜZÜK İHLALİ
2004	23	11	126	97	117
2005	28	13	138	103	250
2006	27	8	163	126	145
2007	31	11	225	166	237
2008	32	9	229	164	206
2009	32	9	223	168	171
2010	36	11	238	163	113
2011	19	7	181	116	113
2012	12	5	132	88	67
2013	14	7	82	48	65
2014	9	1	109	55	39
TOPLAM	263	92	1.846	1.294	1.523
Yıllık Ortalama	24	8	168	118	138

On the other hand, in Dardanelles, encounter and gravel, and malfunctioning has increased from 2012 to 2014 and higher compared to 2004 numbers. Yet, rule violation is consistently decreased from 2005 to 2014.In order to prevent maritime accidents and its destructive results, and provide safe cruise with safety of life and property, Turkish Straits Law has been come into force by Turkish Ministry of Foreign Affairs at 1994. The law rearranged at 1998, at 2002 and at 2006 according to conditions of Bosphorus and Dardanelles In addition, traffic separation schemes TSS, has come into force in 1994 according to the rules of International Regulations for Preventing Collisions at the Sea. In 71th term meeting of Maritime Safety Committee of International Maritime Organization (IMO) in 1999, it was confirmed that traffic scheme conducted in Turkish Straits are effective and successful, and contributes to increasing of cruise safety and decreasing of accidents. However, compared to developed countries, for example United States, statistics of Turkey is not successful enough. In United States, ferry system carries 200 million passengers annually and there were virtually no fatalities between 1904 (the General Slocum ferry incident) and 2003 (the Staten Island ferry incident)

Table 4.4. Dardanelles Accidents Statistics 2004-2014. Altan, T, "Maritime Traffic Analysis of Marmara Sea", January 2014

YILLAR	KAZA (TOPLAM)	ÇATIŞMA VE KUMA OTURMA	ARIZA (TOPLAM)	MAKİNE VE DÜMEN ARIZASI	TÜZÜK İHLALİ
2004	9	6	142	99	144
2005	14	13	172	108	597
2006	11	9	167	127	299
2007	12	12	207	137	293
2008	14	10	219	153	207
2009	7	7	228	131	148
2010	7	6	185	110	104
2011	8	5	136	82	70
2012	5	2	124	72	52
2013	5	4	161	77	70
2014	9	9	170	97	39
TOPLAM	101	83	1.911	1.193	2.023
Yıllık Ortalama	9	8	174	108	184

4.4. Importance of Safety in Ferry Transportation

Safety is the top priority for maritime transportation as well as for ferry transportation. Since 1914, many precautions have been taking care of by the states. Despite its importance, it may be difficult to provide such safety area since flow of safety improvements is rather low. There are many reasons for that. One is, when safety work is successful, there is few accidents happen and this makes governments and companies to give less feedback and act more relax on strict requirements. Also, people tend to interest and try to find solutions on the consequences of an accident rather than its reasons and root causes. Doing something about consequences is always much more expensive than considering of the reasons and taking precautions to prevent the accident. Moreover, safety always involves technological, human and organizational factors and it can be difficult to define potential safety alternatives. Besides companies tend to upgrade the structure of vessel which is not a major cause in the accidents and it is thought to be easier than changing people’s attitude. Also, people have a tendency not to change their behavior when safety is the main issue [19], [50].

5. CASE STUDIES AND RISK ASSESSMENT ABOUT FERRY ACCIDENTS

5.1. Evaluation of Ferry Accidents

The ferries are very special type of vessels due their carrying goods is human. Even minor accident may give rise to loss of life more than anticipated. Therefore, the accidents must be evaluated in detail in order to avoid losses. Risk management on ferries plays a big role in minimizing accidents. When the accidents up to the day were examined, very serious results were encountered. In order to prevent these outcomes, two examples of accidents were discussed and risk management and events were evaluated.

5.2. Case studies

5.2.1. Risk Assessment: Below is the charts of the risk assessment related to preparation for sea including poor visibility and heavy weather condition.

- **Marine Hazard**

COLLISION: Contact with another vessel when both are underway or Vessel making contact with a fixed object.

GROUNDING: Vessel making contact with sea bed or underwater obstruction.

POLLUTION: Potential damage to the environment.

FLOODING: Due to bad weather, but also because of a leak in the ship or from a collision with an object.

FIRE: Potential for injury to persons and loss of goods.

LOSS OF EQUIPMENT: Insufficient equipment used on the vessel.

LOSS OF STABILITY: A problem of Floatability of the vessel, negative changing of the balance.

Corrective actions in the risk assessment are listed in **Table 5.1.**

Table 5.1. Control Measures of Risk Assessment

No	Control Measures
1.	Additional person for lookout / special work.
2.	Preparing signal apparatus for emergency use
3.	Keeping internal communication ready
4.	Awareness training for ship's personnel
5.	All crew are assessed annually for continued competence.
6.	All authorised person are professionally qualified STCW 11/2 (Skills Person)
7.	Safety Management System Procedures
8.	Passage Planning requirements
9.	Speed restriction in the anchorage area, special area….etc
10.	Minimum manning levels when alongside or at sea.
11.	Weather monitoring (Evaluate weather warning)
12.	Wind limitation for safely manoeuvring.
13.	Wind speed and swell height limitations for vessels at sea
14.	Poor visibility restrictions for vessels.
15.	Under Keel Clearance requirements.
16.	Use of Notice to Mariners
17.	Emergency Response Plan about Emergency situations
18.	Hazardous Goods separation aboard vessels/IMDG Code.
19.	Marine Pollution Response Plan
20.	Prevention of pollution and bunkering Operations
21.	Ship stability calculation according to loading master
22.	Ship handling operations. (safely loading, lashing material using, stowing….. Etc)
23.	Safety meetings on board.
24.	Emergency Situations Planned
25.	ICS Bridge Procedures Guide.
26.	Marina operating on VHF Channel 16 & VTS CH.... to supply all navigational information.
27.	Planned maintenance system according to ISM
28.	Ramp safety equipments connected. (pins, bloks,...etc.)
29.	The navigation devices is suitable and in usable (Radar, GPS, AIS, VHF,ECHO SOUNDER, Nav. Lights,..etc.)
30.	Congestion status of navigation area
31.	Informing the passenger and ship personnel with the announce system.
32.	Use of the passenger lounge during the Voyage (Passenger)
33.	Ensuring safe lighting of ferries garages.
34.	Anchor ready to use
35.	Enough bunker for the voyage
36.	Steering system control
37.	Control of watertight compartments
37.	Regular class and flag control, PSC
39.	Ferry General Electricty system operatioanal
40.	Trouble-free operation of garage ramps
41.	Company instructions and circular
42.	Extra measure depending on the type and load of the vehicles

Figure 5.1. Hazard Effect Chart and Risk Matrix, It shows the size of the hazard according to the circumstances and its effect on the risk assessment.

Effect	Severity	PEOPLE	*OPERATION LOSS*	ASSET PROPERTY DAMAGE	ENVIRONMENT	PROBABILITY				
		Definition	**Cost ($)**	**Definition Cost ($)**	**Spill**	**1**	**2**	**3**	**4**	**5**
	A	Multiple deaths, *Multiple* fatality	*>1 M*	*Major Damage* *>1 M*	*>100* Barrel *Major Spill*	H_9	H_{13}	VH_{17}	VH_{19}	VH_{20}
Critical	**B**	*Single* fatality, Multiple severe injuries, Permanent disability	*50K-1M*	*Significant Damage* *50K - 1M*	*1-100* Barrel *Significant Spill*	M_5	H_{11}	H_{14}	H_{16}	VH_{18}
Marginal	**C**	Multiple minor injuries, Major lost time, Temporary disability, Hospital stay	*5K-50K*	*Moderate Damage* *5K-50K*	*>1 Barrel Minor Spill*	L_2	M_7	M_8	H_{12}	H_{15}
Negligible	**D**	Single minor injury, *Minor lost time*, First aid	*<5 K*	*Minor Damage <5K*	Loss of containment on deck or Near Miss	L_1	L_3	M_4	M_6	H_{10}
						Unlike, but may exceptionally occur	Likely to occur some times, possible	Likely to occur several times	Likely to occur often	Likely to be continually experienced

$VH_{17-18-19-20}$	**NON-ACCEPTABLE RISK**
$H_{9-10-11-12-13-14-15-16}$	**NON-ACCEPTABLE RISK REDUCING MEANS ARE TO BE IMPLEMENTED**
$M_{4-5-6-7-8}$	**ACCEPTABLE RISK, BUT RISK REDUCING MEANS ARE TO BE ASSESSED BASED ON COST/BENEFIT ANALYSIS**
L_{1-2-3}	**ACCEPTABLE RISK**

Figure 5.1. Hazard Effect Chart and Risk Matrix

Table 5.2. Probability of Risk Assessment, The frequency of the occurrence of the hazard is stated.

Table 5.2. Probability of Risk Assessment

Probability	**Likelihood**	**Definition**
Frequent	5	Likely to be continually experienced
Probable	4	Likely to occur often
Occasional	3	Likely to occur several times
Remote	2	Likely to occur some times, possible
Improbable	1	Unlikely, but may exceptionally occur

Risk formulation is expressed as Risk = Hazard Effect x Probability. **Figure 5.2.** The risk is also classified between low and very high. L and M indicate acceptable levels, H and VH indicate unacceptable levels of risk.

Hazard Effect (Severity)					
A	H_{9}	H_{13}	VH_{17}	VH_{19}	VH_{20}
B	M_{5}	H_{11}	H_{14}	H_{16}	VH_{18}
C	L_{2}	M_{7}	M_{8}	H_{12}	H_{15}
D	L_{1}	L_{3}	M_{4}	M_{6}	H_{10}
	1	**2**	**3**	**4**	**5**
	Probability				

17-18-19-20	**VH**
9-10-11-12-13-14-15-16	**H**
4-5-6-7-8	**M**
1-2-3	**L**

Risk Factor

Figure 5.2. Evaluation of Risk Matrix

5.2.2. Details of first accident report:

- **Principal Particulars of the Vessel**

Name of the vessel : M/F"MEHMET REIS-11"

Flag : Turkish

Port of regıstry : Istanbul

Imo no : 9378125

Call sign : TCSM2

Constructed in : 2006

Gross tonnage : 644

Net tonnage : 220

L.o.a. : 43.00 m

Breadth / Depth : 12.30 m

Depth : 3.80 m

Figure 5.3. Damage picture of the M/F Mehmet Reis II (Artena marine Survey)

- **Background to the incident**

M/F “MEHMET REIS-11” departed from Bandırma, Balıkesir on 29.01.2010 at 15:30 LT with 358 passengers on board for a routine voyage to Yenikapı, Istanbul. At the time of departure, the wind was blowing from NE up to 4 according to Beaufort scale. When the ferry was sailing off Buyukcekmece at around 17:20 LT, visibility became poor due to showery weather conditions. At that material time, ship’s command was at master, and navigation equipments were all in order / operational. While the ferry was sailing with 27.5 knots speed, the master noticed on the radar that there were two vessels sailing 3 nautical miles ahead.

The master then changed ferry’s course to 10 degrees to starboard and intended to pass from starboard side of M/V “NEW BREEZE”, which was one of the two vessels sailing in the region. As the master thought that this maneuver would be safe enough for clearing from other two vessels, he did not warned them either via Aldis lamp or VHF. At that material time, visibility had decreased up to 1 nautical mile. Although, the master was still thinking that the ferry would safely pass nearby the M/V “NEW BREEZE”, he yet decided to make another cautionary maneuver to prevent from any collision. However, before he made any maneuver, M/F “MEHMET REIS 11” collided with M/V “NEW BREEZE” at the position of LONG 028° 42’ 26” E – LAT 40° 51’ 06” N Just after the accident, deck lightings of the ferry had turned on and the passengers were checked preferentially by crew members. Vessel’s condition was then checked and the accident was reported to the shore management. After consultations with the managers, ferry was decided to resume her voyage to Yenikapı by her own means.

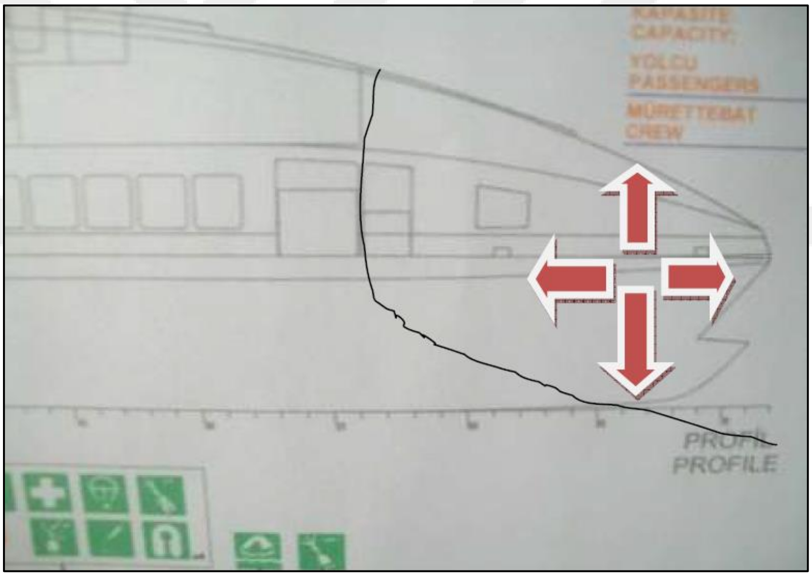

Figure 5.4. Damage drawing of M/F Mehmet Reis II. (Artena marine Survey)

- **Damages found on board the M/F “MEHMET REIS II”**

The damaged fore part of the subject ferry was found covered with tarpaulin sheets and due to stormy weather conditions **Figure 5.3.** She was suffered by the following damages;

- ➢ Port side shell plating, made of aluminium, was found entirely deformed / buckled / torn in size of 7,000 mm x 14,000 mm between frames no. 52-71

- ➢ Forecastle deck at port side was found entirely deformed / buckled / torn together with internal members **Figure 5.4.**
- ➢ 1st passenger floor's top plating were found deformed / buckled / torn together with internal members including electric lines, internal communication lines, air-conditioner lines etc. located under top coating.
- ➢ 4 pieces of glasses in way of 1st passenger floor were found broken.

- **Information about passengers**

A total of 19 passengers were hospitalized on 29.01.2010 just after the accident. 15 out of 19 passengers were discharged from the hospital on the same day after outpatient treatments applied.

- **Damages found on the M/V "NEW BREEZE" (W.P.)**

The following damages were sustained by the vessel; - Stern plate and starboard side aft quarter was found paint scratched - Starboard side aft quarter was found holed in size of 500 mm in between frames no.4 & 5 counting from aft to fore (**Figure 5.5.)** & at 2 – 2.5 meters above sea level between draft marks of 9.50-10.

Figure 5.5. Damages of M/V New Breeze (Artena marine Survey)

- **Probable cause of collision**

According to weather reports, weather was rainy and wind was blowing from NE up to 4 beaufort force. Master's statements and weather reports also revealed that visibility was poor and under 1 nautical mile. It is understood that M/F "MEHMET REIS II" sailing with 27.5 speed was the approaching vessel and M/V "NEW BREEZE" was first seen on the radar screen of the ferry while the distance between the two vessel was about 3 nautical miles. According to the Colreg in force, as approaching vessel, M/F "MEHMET REIS II" had to make immediate cautionary maneuvers and safely pass the M/V "NEW BREEZE".

When we evaluate the incident according to expert reports;
Main cause is human error, Sub-reasons can be said to be high speed, poor visibility, lack of dialogue between two ships and insufficient maneuver.

Table 5.3. Control Measure Scales on M/F Mehmet Reis II

Ship: M/F Mehmet Reis II	**Location of Task:** Marmara Sea	**Date:** 29.01.2010
Description of Task: Preparetion for Safe navigation inculuding poor visibility condition.		
Reason for Risk Assessment: Prevent accıdent that may occur		
Assessment Team Members: DPA, MASTER, CHF. ENG.		

Hazard Identification	Hazard Effect	Severity	Probability	Risk Level	Safeguards needed to control risk to acceptable level "CONTROL MEASURES"	Residual Risk Factor			Accept Risk?
						Severity	Probability	Risk Level	
COLLISION	Catastrophic	A	3	VH_{17}	1,2,3,4,5,6,7,8,9,10,11,12, 13,14,16,17,23,24,25,26, 27,29,30,33,35,40	C	3	M_8	✓
GROUNDING	Catastrophic	A	3	VH_{17}	1,3,4,5,6,7,8,9,10,11,12,13,14, 15,16,17,21,23, 24,25,26,27,29,30,33,34,35,40	C	3	M_8	✓
FLOODING	Catastrophic	A	3	VH_{17}	3,4,5,6,7,10,12,13,15,16, 17,21,23,24,27,29,32,36,40	D	3	M_4	✓
FIRE	Catastrophic	A	2	H_{13}	3,4,5,6,7,10,17,18,20,23, 24,27,29,31,36,38,40	D	2	L_3	✓
POLLITION	Marginal	C	2	M_7	2,3,4,5,6,7,9,10,15,16,17, 19,23,24,26,27,29,31, 35,40	D	2	L_3	✓
LOSS OF STABILITY	Catastrophic	A	2	H_{13}	3,5,6,7,10,12,13,15,16,17, 21,23,24,26,27,29,36,40	D	2	L_3	✓
LOSS OF EQUIPMENT	Critical	B	3	H_{14}	2,3,4,5,6,7,9,10,11,12,13,16,17, 23,24,27,29,31,32,33,34,35,38	C	3	M_8	✓

☐ *We are **NOT** satisfied with the safeguards available to control risk and we recommend that this task should not proceed until further risk control measures can be developed.*

As can be seen in the presented risk assessment table **(Table 5.3.)**, it has been tried to reduce the possible risks by increasing the measures and taking additional measures. As a result of these operations, the factors causing the accident were largely eliminated.

5.2.3. Details of second accident report:

- **Principal particulars of the vessel**

Name of the vessel: M/F ”HAMİDİYE” **(Figure 5.6.)**
Flag: TURKISH
Port of regıstry: Istanbul
Imo No: 9717577
Call sıgn: TCA3466
Constructed ın: 23.10.2013
Gross tonnage ex / new: 943 / 1247
Net tonnage ex / new: 588 / 382
L.O.A.: 90 m
Breadth: 18.096 m
Depth: 3.90 m
Ramp Length: 775 cm
Ramp Breadth: 1140 cm

Figure 5.6. Picture of M/F Hamidiye

- **Background to the incident**

The M/F Hamidiye departed from Tavsanli port at 1800, on 30.12.2016, it was making a trip in Izmit bay to reach Eskihisar port. There were no problems on navigational equipments, control panels and veth systems, As a result of the sudden gust of air (NNW 8-7), the captain changed the course by 15 degrees in order to avoid a heavy rolling of the ship. However This maneuver, did not reduce the negative impact of heavy waves on the head of the ramp. The heavy sea forced the head ramp of the vessel. The head ramp released from the safety hook and caused the ramp to overload.

The ramp break without being able to withstand the weight. The ramp fell to the sea. Due to the heavy air and the forward inertia of the ship, the hinges of the ramp are cut off. The ramp was buried in the waters of İzmit bay. The ship was rushing back to avoid the waves in the main garage, but the heavy seas entering the garage during this time caused material damage. The ship came back to the pier of Tavşanlı and discharged the vehicles in the garage.

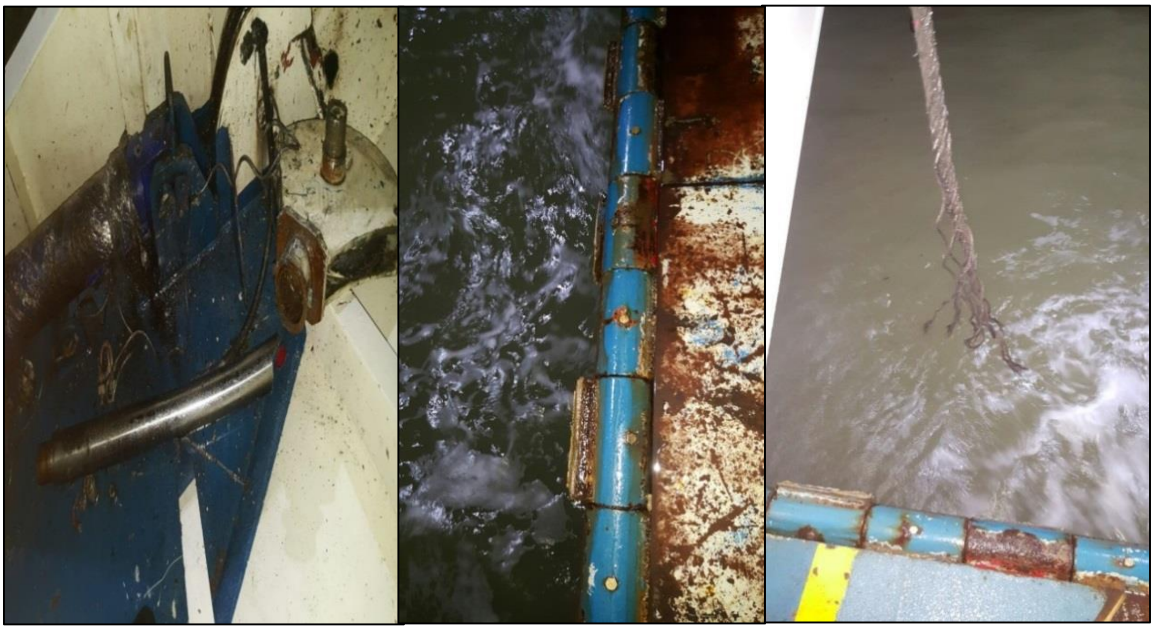

Figure 5.7. Damages of M/F Hamidiye after the Accident

- **Damages found on board The M/F "HAMİDİYE"**

➢ 8 vehicles were damaged in medium and small size.

➢ The ramp of the main garage head ramp of the ship fell to the sea. **(Figure 5.7.)**

- The ramp's hydraulic system has become completely unusable.
- Wire ropes holding the ramp become unusable.
- The stanchion on the platform was broken. (about 2 meters in the *area*)

Figure 5.8. Safety Hooks On M/F Hamidiye Ramps

- **Probable cause of Incident**

The weather has been reported to be too heavy for these ferries, according to weather reports. In addition, the hooks used for the safety of the main garage ramp do not provide adequate safety when the situation is examined. **(Figure 5.8.)** As a result of the use of the hook, the space between the ship's front and the ramp is a threat. Under these circumstances, it was concluded that the measures taken were insufficient and the ship's ramp was not adequately safeguarded. It is likely that the resulting accident is likely to occur when the weather conditions are taken into consideration. The use of the safety pins and blocks could provide a safer position by completely closing the ramp. **(Figure 5.9.)**

Figure 5.9. Safety Bloks on M/F Hamidiye

When we evaluate the incident according to expert reports; Main cause is insufficient voyage preparation, Sub-reasons can be said to be human error, insufficient of ramps safety.

Table 5.4. Control Measure Scales on M/F Hamidiye

Ship: M/F HAMİDİYE	**Location of Task:** GULF OF IZMIT	**Date:** 30.12.2016
Description of Task: Preparetion for sea inculuding poor visibility and heavy weather condition.		
Reason for Risk Assessment: Prevent accıdent that may occur		
Assessment Team Members: DPA, MASTER, CHF. ENG.		

Hazard Identification	Hazard Effect	Severity	Probability	Risk Level	Safeguards needed to control risk to acceptable level “CONTROL MEASURES”	Residual Risk Factor			Accept Risk?
						Severity	Probability	Risk Level	
COLLISION	Catastrophic	A	3	VH_{17}	1,2,3,4,5,6,7, 10,11,12,13,14,16,17,23, 24,25,26,27,29,30,33,35, 40	C	3	M_8	✓
GROUNDING	Catastrophic	A	3	VH_{17}	1,3,4,5,6,7, ,10,11,12,13,14,15,16,17,21,22,23 24,25,26,27,29,30,33,34,35,40	C	3	M_8	✓
FLOODING	Catastrophic	A	3	VH_{17}	3,4,5,6,7,10,12,13,15,16, 17,21,23,24,27,28,29,32, 36,39,40	D	3	M_4	✓
FIRE	Catastrophic	A	1	H_9	3,4,5,6,7,10,17,18, 22,23,24,27,29,31,36,38, 40,41	B	1	M_5	✓
POLLITION	Marginal	C	2	M_7	2,3,4,5,6,7,9,10,15,16,17, 18,19,20,22,23,24,26,27, 29,31,35,40,41	D	2	L_3	✓
LOSS OF STABILITY	Critical	B	2	H_{11}	3,5,6,7,10,12,13,15,16,17 ,18,20,21,22,23,24,26,27, 29,36,40,41	D	2	L_3	✓
LOSS OF EQUIPMENT	Critical	B	2	H_{11}	2,3,4,5,6,7,9,10,11,12,13,16 ,17,18,22,23,24,27,28,29,31 ,32,33,34,35,37,38,39	C	2	M_7	✓

☐ We are **NOT** satisfied with the safeguards available to control risk and we recommend that this task should not proceed until further risk control measures can be developed.

As can be seen in the risk assessment table **(Table 5.4.)** in this accident example, it has been tried to reduce the possible risks by increasing the measures and taking additional measures. As a result of these actions, the factors causing the accident were largely eliminated.

6. CONCLUSION

Ferry accidents may cause to injuries and deaths of people, environmental pollution and also damage to vessels and stuffs or customers. To provide safety, it is important to do risk analysis and manage the risk. In this review, it was analyzed that what is risk and risk management and what contributes ferry risk management, what are the benefits of ferry risk management. By managing the risk, risk conditions are controlled, risky situations are handled and risk that may occurred will be minimized. We also use some examples of ferry accidents that has been occurred recently and what were the results of these accidents.

As a result of the review, the following factors and recommendations should be examined to get maximum benefits by using risk management to avoid possible accidents.

- **Human Error:**

The most important factor that increases the risk in ferry accidents is the human error. Strictly advice to establish serious training process including that lower cost technology to assist master and other person. This process should be support simulation technic for well understanding by ships crew. Finally necessary the improving background to arising crew motivations.

- **Weather Conditions:**

Adapting advanced systems to local maritime transport, which can provide detailed information on weather reports reduses accidents. In addition, vessels used in areas with heavy marine conditions should be built more resistant.

- **Overloading and Overcrowding:**

Inspections can be increased so that ferries do not cross the appropriate loading line. In addition, loading limits can be checked with sensors that can be tripped during loading.

- **Other Causes:**

any case Company Owners get most of the responsibility which cases could be occure due to pair safety standarts. For this reason, companies must create a strategy according to the area of the worked region. As well as increasing the responsibilities of the company and the port authority to make ferries voyage suitable, will reduce the pressure on the captain and create a safer environment. On the other hand, detailed examination of the ferry accidents and database creation will help reduce the risk of accidents.

In future research, not only assess ferries risk but also ferry ports risks should be investigated to reducing the ferry accident and defined common precautions.

For the furture research evaulate build more techonologic ferry vessel equipped authomatic warning/fixed problem system in case of emergency situation to assist crew members on board meanwhile established data network between ferries, control sitation and search/rescue centers.

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