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Κατσαμάκη Αργυρώ

Διπλωματική Εργασία

που υποβλήθηκε στο Τμήμα Ναυτιλιακών Σπουδών
του Πανεπιστημίου Πειραιώς ως μέρος των
απαιτήσεων για την απόκτηση του Μεταπτυχιακού
Διπλώματος Ειδίκευσης στην Ναυτιλία

Πειραιάς

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- κα Γκατζόλη Ανδρονίκη
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ΕΥΧΑΡΙΣΤΙΕΣ

Στο σημείο αυτό θα ήθελα να ευχαριστήσω όλα τα μέλη της τριμελούς εξεταστικής επιτροπής, και ιδιαίτερα τον κύριο Παντουβάκη, για την πολύτιμη βοήθεια τους και τις συμβουλές τους καθ'όλη την διάρκεια εκπόνησης της παρούσας διπλωματικής εργασίας.

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ΠΕΡΙΛΗΨΗ

Η εν λόγω διπλωματική εργασία ασχολείται με την κατηγοριοποίηση και τις μελέτες περιπτώσεων ναυτικών ατυχημάτων. Αποτελείται από δύο μέρη. Στο πρώτο μέρος ορίζεται το ναυτικό ατύχημα, χωρίζονται τα ναυτικά ατυχήματα σε κατηγορίες και περιγράφονται τα αίτια που τα προκαλούν. Παράλληλα αναφέρονται περιληπτικά παραδείγματα σε κάθε κατηγορία για καλύτερη επεξήγηση της επιστημονικής θεωρίας. Στο δεύτερο μέρος, παρουσιάζονται δύο μελέτες περιπτώσεων πρόσφατων ναυτικών ατυχημάτων πλοίων της επιβατηγού ναυτιλίας, τα οποία συγκλόνισαν την παγκόσμια κοινή γνώμη. Η πρώτη αφορά το πλοίο γραμμής Sewol το οποίο βυθίστηκε στις 16 Απριλίου 2014. Η δεύτερη μελέτη αφορά το κρουαζιερόπλοιο Costa Concordia το οποίο προσέκρουσε σε ξηρά στις 13 Ιανουαρίου 2012. Οι μελέτες περιπτώσεων έχουν συγγραφεί σύμφωνα με τις δημοσιογραφικές αναφορές και έρευνες που έχουν δοθεί στην δημοσιότητα μέχρι σήμερα.

Λέξεις Κλειδιά: *ναυτικά ατυχήματα, κρουαζιερόπλοιο, Sewol, Costa Concordia*

ABSTRACT

This dissertation paper deals with the categories of maritime accidents and case studies of them. It is composed by two parts. In the first part it is defined what a maritime accident is, the accidents are categorized and the factors that cause them are being analyzed. Moreover, some examples are being displayed referring to each of the categories, for a better explanation of the scientific theory. In the second part of the dissertation paper, there are presented tow cases studies of two recent maritime accidents of passenger vessels, that shocked the shocked the public opinion internationally. The first case study is about MV Sewol, a passenger vessel which sank on 16th of April 2014. The second case study refers to the grounding of the cruise ship Costa Concordia, an accident which occurred on 13th of January 2012. The case studies have been conducted in regards to the media reports and inquiries that have been published until today.

Keywords: *maritime accidents, passenger ships, Sewol, Costa Concordia*

CHAPTER 1 - INTRODUCTION

The maritime transport system is vital for the worldwide economy and the society. Sea transportation remains through the centuries as the most cost effective and environmentally friendly way of getting goods from one side of the world to the other. However, everything comes with a cost and the maritime incidents cost around $1 million per day. As a maritime accident or casualty we characterize every maritime incident which has as a result the loss or the damage of the ship or of its cargo. Marine accidents adversely affect the human, the marine environment, and properties and activities aboard ships and ashore in various forms and degrees of extent. The effects of accidents vary from minor injuries to fatalities and from insignificant damage to very severe damage to the environment and property.

The aim of this paper is to present the different categories of maritime accidents that occur every day in the oceans and the seas of our planet and emphasize to the great range of them. Never an accident is the same with another. They usually present some similarities, according to which they have been categorized. A special notice is given to the passenger vessels' accidents. Accidents of passenger ships are not so often, although they are of great interest, taking into consideration the number of human lives they are in danger each time such an accident occurs.

In the first part of the paper we describe as follows:

In the 2nd Chapter, we present the definition of the maritime accidents according to the International Maritime Organization and their levels of severity.

In Chapter 3, we analyze the different categories of the maritime accidents by two points of view: the maritime accidents by vessel type and the maritime accidents by the type of the event. For each category, an example is described briefly. We tried to choose popular wrecks and accidents to explain the theoretical words of the document. A brief description of the accidents that may occur in ports is being presented at the end of the chapter.

In Chapter 4, in accordance to the researches and the shipping reviews published for the previous years from the Allianz and EMSA, we present statistics for the marine casualties that occurred during the past year 2013. At the time that the paper was written we could not have a complete statistical image for the year 2014.

In Chapter 5, we analyze the main factors that contribute to the occurrence of a marine casualty, which are the human factor, the age and the design of the ship, the weather conditions, the mechanical failures and the lack of operating standards. In addition, we are describing the impact of a marine casualty in the economy, the environment and the society.

The second part of the paper includes the two case studies. In Chapter 6, the first case study is about the MV Sewol. The passenger vessel sank on 16 of April 2014 off South Korea, costing the life of 302 people. Official report has not been published yet. We are presenting a timeline of the events and the possible factors that led to that tragedy. In addition, we are presenting the events after the accident, as well as all the background regarding the Korean Shipping Association and the Korean Register of Shipping.

The second case study, the one of Chapter 7, is about the shocking disaster of the cruise ship Costa Concordia, on January 2012. In that accident 32 people lost their lives. Along with the timeline of the actions that followed each other to result to the grounding, we are presenting the main contributing factors as mentioned by the official reports. Moreover, the salvage operation of the vessel is of great interest and described in the next pages.

Finally, Chapter 8 is all about conclusions made by the author of this paper, most especially about the significant role of the human element in the occurrence of marine accidents.

PART I

CHAPTER 2 - WHAT IS A MARINE ACCIDENT?

2.1 THE DEFINITION OF THE MARINE ACCIDENT

According to the Regulation A846 adopted on 27TH November 1997 by the IMO **Marine casualty** means an event that has resulted in any of the following:

- the death of, or serious injury to, a person that is caused by, or in connection with, the operations of a ship
- the loss of a person from a ship that is caused by, or in connection with, the operations of a ship
- the loss, presumed loss or abandonment of a ship
- material damage to a ship
- the stranding or disabling of a ship, or the involvement of a ship in a collision
- material damage being caused by, or in connection with, the operation of a ship
- damage to the environment brought about by the damage of a ship or ships being caused by or in connection with, the operations of a ship or ships.

In regards to the level of the seriousness, we divide the maritime accidents as follows:

1. Very serious casualty means a casualty to a ship which involves the total loss of the ship, loss of life or severe pollution (Casualty Investigation Code, 2008). These are accidental situations where either the safety measures have not been implemented properly or have failed, or as manifestations of a poor safety culture. All safety measures and regulations have been designed to ensure the safety at the sea at all levels. The notion of a "safety culture" normally refers to the principles underlying operations that govern the performance of daily work and decision making.

2. Serious casualty means a casualty which does not qualify as a very serious casualty and which involves:

- a fire, explosion, grounding, contact, heavy weather damage, ice damage, hull cracking or suspected hull defect, etc., resulting in
- structural damage rendering the ship unseaworthy, such as penetration of the hull underwater immobilization of main engines, extensive accommodation damage etc.
- pollution (regardless of quantity)
- a breakdown necessitating towage or shore assistance.
  (UK MAIB- Marine Accident Investigation Branch, 2012)

3. Marine incident means an occurrence or event being caused by, or in connection with, the operations of a ship by which the ship or any person is imperiled, or as a result of which serious damage to the ship or structure or the environment might be

caused.
(UK MAIB- Marine Accident Investigation Branch, 2012)

The last two categories both refer to accidents that usually result in economic loss. There are situations where because of the right follow up in the safety measures and regulations, a further catastrophe can be prevented. Even a lucky coincidence can prevent a very serious accident from occurring.

Further to the above, there are of various near misses, hazardous situations and breaches of safety regulations (deviations). Information on these incidents is currently limited to data obtained from a port state control inspections, ship surveys and Vessel Traffic Service VTS reports. In such situations we can presume that again safety measures have failed, but this time the series of events did not led to a serious accident or to a serious damage.

Generally speaking, the problem of the marine accidents is an international problem and needs to be faced by internationally common implemented solutions. The confrontation of the marine casualties is a key focus of quality shipping, and this premises a strict observance of the rules for the safety at the sea.

CHAPTER 3 - TYPES OF MARINE CASUALTIES

The different types of accidents that have occurred during the centuries are numerous. Each accident has its own specificity, occurs for a different series of reasons each time. So we can only find similarities among the accidents, but never the exact same one twice. However, the European Maritime Safety Agency (EMSA) categorizes the marine accidents taking into consideration two factors: the type of the vessel and the type of the event.

3.1 ACCIDENTS BY SHIP TYPE

The accidents by ship type are divided in the following six (6) categories (EMSA, Maritime Accident Review):

1. Cargo Ships
2. Tankers
3. Container Ships
4. Passengers Ships
5. Fishing Vessels
6. Other types of vessels

3.1.1. CARGO SHIPS

In this category the types of ships that are included are the following: general, ro-ro and refrigerated cargo ships, bulk carriers and vehicle carriers. So, we are referring to the majority of commercial ships. The accidents in which they are usually involved are collisions/contacts and groundings, fires and explosions. One of the main concerns about the safety of the ships in this category, and especially of the bulk carriers is the loading of the cargo. All procedures related to the loading must be done carefully to avoid any shift of the cargo during the trips and ensure the stability of the vessels.

As an example of this category, we will have a brief look on a collision between a bulk carrier and a general cargo ship in the Singapore Straits. The accident involved the Bulk carrier Southern Explorer, a 289m long cargo chip built in 2002, and the cargo vessel Best Unity, a 224,8m long bulk carrier built in 1997. Both vessels were registered in Panama. The accident occurred on 12th September around 2:30 p.m. UTC. The vessels were in opposite directions – the Best Unity was en route from Taiwan in ballast while Southern Explorer was heading to Taiwan fully laden [1]. Both vessels suffered a significant damage. Such coincidental accidents usually are a result of potential consequences.

[1] http://www.vesselfinder.com/news/

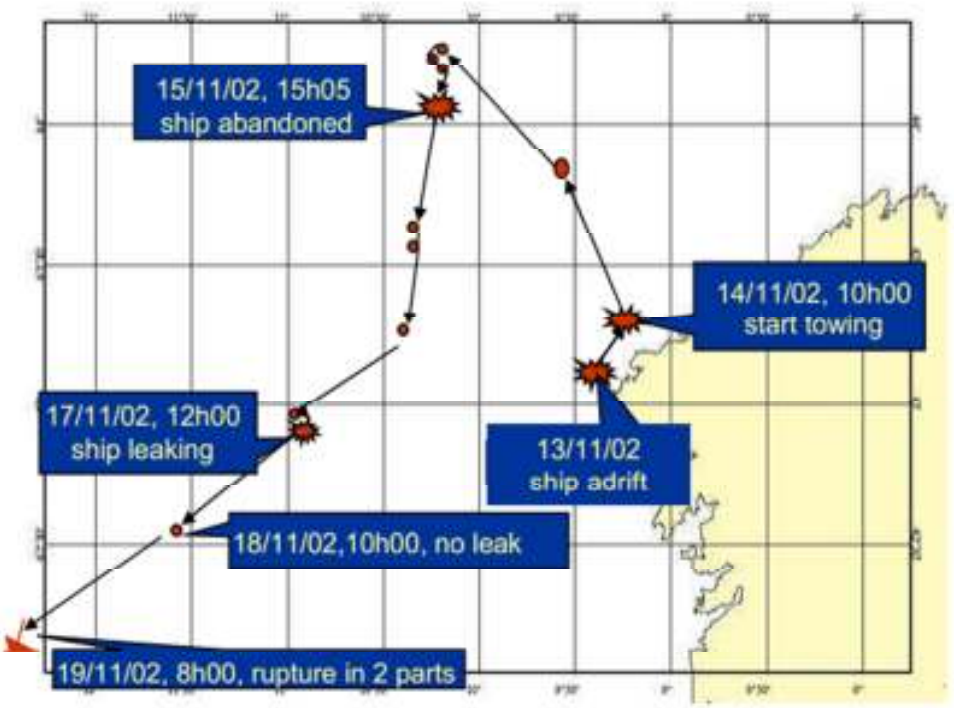
3.1.2. TANKERS

In this category belong all types of tankers as LNGs, LPGs, and chemical tankers. Tankers are often involved in collisions. Tanker accidents can be very serious as due to oil spills they can cause damage to the marine environment and coastal pollution. This is the reason why the vast majority of tanker vessels operating in and around EU and US waters are now double hulled, in line with the international requirement to phase out single hulled tankers. Oil spills also involve high acute costs through clean-up operations (Montewka et al., 2013) and have a considerable impact on affected economic activities (Crotts and Mazanec, 2013).According to statistics, one of the main reasons for oil tanker accidents occurring is because of workers' negligence – nearly 84-88% [2].

As an example, we can have a brief review of the well-known tanker's "The Prestige" accident. Prestige was 26 year old Bahamian registered and American Bureau of Shipping (ABS) classed single hull tanker, carrying 77,000 tons of heavy oil (fuel No6). The vessel departed its loading port of Riga, Latvia, on 5 November 2002 (Maritime Safety Security and Piracy, 1st edition 2008). Prestige was built by Hitachi Zosen, in Japan in 1976. The ship had a deadweight of 81,564 tons, she was 243,5 meters long with 43,4m width and 14m draught. The vessel was taking the complete route from St. Petersburg (Russia) to Ventspills (Latvia) to Singapore via Gibraltar. On 13 November, Prestige developed a substantial starboard list when she was underway in heavy seas and high winds in the region of Cape Finisterre, between 25 and 30 nautical miles off the Coast of Galicia in the north-west of Spain (ABS, 2002).

A large crack was found in the starboard side of the hull and with the loss of her main propulsion due to list she began to drift. The ship was towed out to sea into heavy weather away from the Spanish coast and for 5 days she was speeling oil. The condition, however, deteriorated on board. Consequently, Prestige structure gave way and collapsed. Subsequently the vessel broke into two and sank about 133 nautical miles (250km) off the coast of Spain on 19 November 2002 (Wang, 2006). In the map below, we present a timeline of the events:

[2] http://www.marineinsight.com/misc/marine-safety



Map 3.1.: Timeline of the Prestige Accident. (Source: www.cedre.fr)

The Prestige tanker accident seriously polluted the Spanish coast by oil spills and shocked the public. It was after that accident that the procedures for the development of a common European Safety Policy accelerated. The attention focused on tanker safety improvements. Under new rules adopted by the EU, single hull tankers carrying heavy oil have already been banned from EU ports. The ban brings EU in line with the US, which restricted single-hull tankers carrying heavy oil from its waters 3 years after the 1989 Exxon Valdez disaster. The EU's ban came a year after the Prestige tanker accident (Wang 2002 and 2006).

3.1.3. CONTAINER SHIPS

Compared to other vessel types, container ships have a very good safety record and in recent years the accidents of this category have been reduced (Payer, 2002). This can be considered as a benefit, taking into consideration that the accidents of container ships can be very expensive. The total cost is estimated to 359.000 US$ per ship and per annum for a 4500 EVP ship (panamax size). Transposing the statistics of small ships to new large ones gives figures of about 700.000 to 800.000 US$ per ship and per annum value of the cargo not included [3].

[3] http://www.afcan.org/

According to the FSA (Formal Safety Assessment) the main dangers which are associated to the container ships are damage to the hull and to the engine, collisions and fire to the containers, parametric rolling, extensive wave loads, safety of containers on the deck and others. We will refer more extensively on the most important.

Fires in containers were the subject of many press articles these last years. A fire in a containership can occur by sensitive cargoes such as the calcium hypochlorite. Many times a fire can lead to an explosion and cause even more serious damage. Moreover, as oxygen is released from the burning product, the fire is outspreading and thus the extinguish job can be very difficult. To limit the possibilities of such accidents, the IMO had developed the International Maritime Dangerous Goods (IMDG) Code, a uniform international code for the transport of dangerous goods by sea covering matters as packing, container traffic and stowage [4]. An example of a large fire that resulted in the abandonment and the loss of the vessel was the one of Hanjin Pennsylvania, in December 2003.

The integrity of the hull is normally not a problem for container ships. MSC Carla was the first container ship that broke in two in the winter storms 1997/1998 (Payer, 2002). The container ships were always built with double side plating, double bottom and watertight bulkheads. Therefore, their structure provides them with strength and stiffness.

Containerships, with their usually fine lines, can experience heavy rolling in following seas, depending on the wave conditions in relation to the dimensions of the ship. This phenomenon referred to as parametric rolling (Payer, 2002) and was the cause of very heavy losses of containers these last years. A traditional example of this phenomenon is the one of APL CHINA in 1998. The vessel survived from a 24hour hurricane, but lost 406 containers, with more than 1,000 damaged. Parametric rolling can occur by heavy seas with an unfavourable combination of wave height, typhoons, length and period according to the ship length. A sudden rolling may occur without notice, making the piles of containers rock like dominos, producing severe losses [5].

We will shortly describe here a recent marine accident of the MSC Napoli container ship that was caused by cracks. The problem of cracks in the hull of the container ships was observed at a large scale the recent years. Although the structure of the container ships is very strong, the everyday use causes the hull to face fatigue. The accident of MSC Napoli occurred on Thursday 18th of January in the English Channel.

[4] http://www.imo.org/OurWork/Safety/Cargoes/Pages/DangerousGoods.aspx

[5] http://www.dnv.in

MSC Napoli was a 275m long and 4419TEU container ship which was caught in stormy weather with 9m high waves. Because of the weather conditions she pitched heavily and suffered structural damage. The vessel suffered a catastrophic failure of her hull in way of her engine room. Cracks began to appear in the engine room which became progressively worse and resulted in a 1m by 0.5m hole, developing in the starboard side of the vessel. The vessel began to take in water through this hole. The 26 crew members were forced to issue a distress call and abandon ship in favor of a lifeboat [6]. For good, there were no injuries.

The investigation which was made later has identified a number of factors which contributed to the failure of the hull. One of those factors was that the ship had a service speed of 11 knots but she did not reduced in the heavy seas. As we mentioned above, such accidents result to very big economic costs. To the case of MSC Napoli, the London Steamship Owners Mutual Insurance Association revealed the insurers estimate of the bill for the wreck, including the salvage operation, clean up, vessel and cargo costs was £ 120 million [6].

3.1.4. PASSENGER SHIPS

The category of Passenger Ships includes Ferries, Cruise ships and Mega Yachts (Commercial or Pleasure). According to the IMO, a ship is defined as passenger if she is carrying more than 12 people. Passenger ships are subject to a vast array of regulations and standards covering every aspect of ship construction and operation. These regulations are focusing both on the technical – organizational safety requirements and on the safety of the "human element" [7].

Though they are rare, passenger ships accidents range in severity with usually catastrophic results. Here the main victim of an accident is the loss of human life. Environmental pollution does not play a significant role. The safety culture of the ships which belong in this category has many times been criticized and questioned by the Safety Investigation Authority. The inspectors have concluded to the fact that a safety culture does exist, but its guidelines need several improvements. We can have a short but closer look to a very well-known accident of this type, the Estonia accident.

The passenger ferry Estonia was registered as a Ro-Ro Passenger Cruise Vessel with a capacity of 15,566 grt and deadweight 2,800 tons. In regards to the dimensions, the vessel had 157,02m length, 24,21m beam and 5,55m draught. MV Estonia departed port of Tallinn, the capital of Estonia, on 27 September 2004 at 19.15 hours, for a voyage to Stockholm, Sweden.

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[6]http://www.ship-disasters.com

[7] http://www.imo.org/OurWork/Safety/Regulations/Pages/PassengerShips.aspx

Estonia had 9 decks and could carry on 2,000 passengers, 1,190 passenger births and 460 cars. During the described trip, she carried 989 people, 803 of whom were passengers. She got caught up in the storm, capsized and sank in the northern Baltic Sea in the early hours of 28 September 1994. The accident cost in total 852 lives. Along with victims were 501 Swedes, 282 Estonians, 10 Finns, 17 people of Latvia and 44 people from other countries including Canada and Nigeria [8]. So it was an international disaster. According to the Accident Commission, the cause of the accident was that the design and manufacture of the bow visor locks were wrongly conducted, resulting in the locks being too weak. During bad weather conditions the locks were broken and the visor fell off and pulled open the inner bow ramp (Wang 2002) and as a result water was loaded in the superstructure. The water flooded the main Ro-Ro deck and the vessel lost stability and sank. Estonia, at her last voyage, was not seaworthy and she did not fulfill the SOLAS requirements. The crew also made mistakes, which partially contributed to the loss of so many lives (Wang 2002, Wang and Trbojevic, 2007).

The Estonia tragedy also resulted in a surge of research into the phenomenon of Ro-Ro damage survivability and was instrumental in the adoption of the North European regional damage stability standard in SOLAS 95 and the Stockholm Agreement. These standards require the upgrading of virtually every passenger Ro-Ro ship operating in Northern Europe (Psaraftis, 2002).

3.1.5. FISHING VESSELS

Fishing remains for years one of the world's most dangerous job. The severity of the accidents in this category is reflected in terms of lives lost in the international waters each year. These kinds of ships present a high casualty rate and suffer severe consequences when an accident happens. The safety of this category has been a matter of concern since a lot of years. IMO had published the "Fishing Vessel Safety Code and Voluntary Guideline" and the "Safety recommendations for decked fishing vessels of less than 12 meters in length and undecked fishing vessels [9]. Many of these vessels due to their size lack of stability when they sail in bad weather conditions. Some other factors are the competency of the crew, fatigue, poor manning of vessel, difficult operating conditions, poor design and inappropriate regulations. The result is 24,000 human losses annually.

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[8]http://latvianhistory.com

[9] http://www.imo.org/OurWork/Safety/Regulations/FishingVessels/Pages/Default.aspx

Comparisons of the safety record of the fishing industry with other industries indicate that the industry continues to be the most dangerous by a significant margin. One of the main causes why the accidents of fishing vessels are fatal in many cases, are the falls overboard. The effective use of lifejackets is essential. The shooting or hauling of fishing nets is a particularly high-risk task, with workers drowning or suffering injury after being struck by or entangled by fishing tackle. Falls and being struck by moving objects (such as trawl equipment) are very common fatal and non-fatal accidents [10].

The fact that on board fishing vessels the number of the crew is small and they perform too many tasks at the same time is also a reason for the accidents. Bad weather conditions and short turn around times can increase accident risks. Many of the seafarers on those ships are being victims of the unpredictable weather changes. Being at sea means that, in many cases, the consequence of an accident is more severe than if it happened on land. Snagging of nets leading to capsize of a vessel or a worker being dragged into a winch or similar equipment are other causes of fatal accidents.

3.1.6. OTHER TYPES OF VESSELS

In this category, we can include Supply/offshore vessels, tug vessels, dredger vessels and any unknown types of ships. For example, in tug vessels when something goes wrong it goes wrong very fast and often with fatal consequences. We will describe shortly the accident of the tug boat North Tug.

The accident occurred on the 10th of June 2013. The workboat North Tug capsized and sank while it was assisting the cruise ship Ocean Princess during its departure from the quay in Kirkenes [11]. According to AIBN (Accident Investigation Board Norway) report for the accident the plan was to move the cruise ship sideways out from the quay, and North Tug was to assist in pulling the bow of the cruise ship away from the quay. A change in the initial plan which was not communicated to the crew led to North Tug being pulled along by the cruise ship and moving backwards with the towline over its stern. The aft deck started to fill up with water because of the speed at which she was moving, which caused the boat to heel. The tug capsized as a consequence of water on deck and the transverse forces from the towline. The two crew members on board jumped into the water and finally saved themselves.

North Tug was not a certified tugboat. Moreover the crew on board the tug vessel did not have the necessary knowledge and expertise to handle the big tonnage of Ocean Princess. In the whole process the plan was inadequate and there was lack of communication.

[10]https://osha.europa.eu/en/faq/accident-prevention-1/

[11] http://www.cargolaw.com/presentations_casualties-13.php

3.2. ACCIDENTS BY THE TYPE OF THE EVENT

Marine accidents can be categorized in regards to the type of the event that each time occurs. Taking into consideration the more recent years' statistical reviews of THE European Maritime Safety Agency (EMSA) , we are listing the most commons types of events below :

1. Sinkings
2. Groundings
3. Collisions/Contacts
4. Fires/Explosions
5. Other types of events

3.2.1. SINKINGS

One of the most common types of marine casualties is the sinking of a vessel. The sinking of a vessel is often caused by bad weather conditions. However the sinking is also caused in many cases by a ship's cargo shift in a storm. Finally there are several cases where a leak may develop somewhere in the vessel's structure and as a result the ship will capsize and eventually sink.

According to the Allianz Safety and Shipping Reviews in 2012 the marine accidents of this type numbered 52 and in 2013 around 69. The most famous case in 2012 was probably that of the cruise ship Costa Concordia, which ran aground on Italy's West Coast and sank in January 2012 and which will be analyzed more later. In total 32 people lost their lives in this accident. That accident has become the reason why the passenger ship safety improvement is being a priority, especially in Asia where quality standards are still low. Another significant sinking was the one that occurred on the 27th of September 2008. In this latter case, the 400gt cargo ship Tolstoy sank in the Black Sea of Cape Emine in Bulgaria due to the strong wind and as a result 8 crew members lost their lives [12].

In this paper, we will describe shortly another well-known sinking, that one of the Herald of Free Enterprise. The passenger vessel Herald of Free Enterprise capsized four minutes after living the Harbour of Zeebrugge. The accident occurred of 6th of March 1987. As a result, at least 150 passengers and 38 crew members lost their lives. The Herald of Free Enterprise was a Townsend Thoresen branded Ro-Ro passenger and car ferry owned by European Ferries. The ferry was built by Schichau Unterweser AG, Bremerhaven 1980. She was registered at Dover and was 7951,44 tons gross and 3439,05 tons net register. Her length was 131,9m overall, 121,1m between perpendiculars and breadth 22,7m molded. The vessel was capable of a service speed of 22 knots.

The capsizing of Herald of Free Enterprise was caused by a combination of adverse factors. Those which have been identified were the trim by the bow, the bow door being left open, the speed of the vessel just before capsizing and the location of the ship's center of gravity. Their combined effect was to cause a quantity of water to enter G-deck and loss of the vessel's stability (Wang, 2002). The human actions and decision in this specific case have been the main contributors to the undesirable result. These ranged from weakness in the management of safety to human errors, caused by various factors including a heavy workload. The basic Ro-Ro ferry design was questioned, in particular the single compartment standard for G-deck. There were no watertight bulkheads at all on this deck to prevent the free surface effect along the full length of the vessel.

The public inquiry into the accident of Herald of Free Enterprise led by Lord Carver was a stepping-stone in ship safety. It has resulted in changes of marine safety-related regulations. The loss triggered a shift in international maritime safety from reactive response to a 'safety culture' oriented philosophy currently imposed through the International Safety Management Code (Gill et al. 2012). It has resulted in changes of marine safety-related regulations demonstrated by the adoption of the enhanced damage stability and watertight closure provisions in SOLAS 90, the introduction of the ISM Code for the Safe Operations and for Pollution Prevention, and the development of the FSA framework in the shipping industry (Wang, 2002).

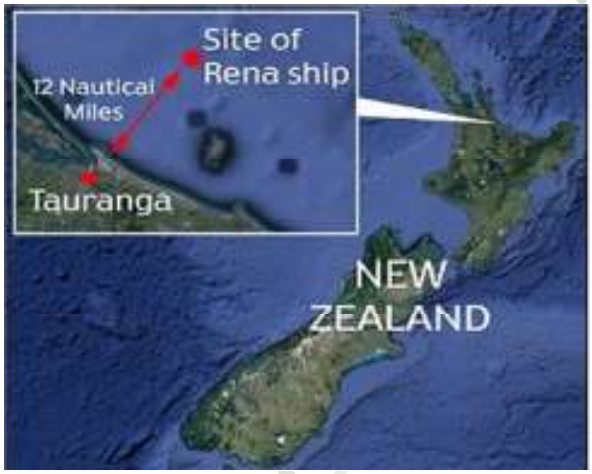
3.2.2. GROUNDINGS

The second most common type of marine accidents is the groundings. Groundings usually occur when a vessel runs aground or in other words touches the bed of the body of water.

The consequences of such an accident refer to the structure of the ship, environmental distress and loss of human life. Grounding can lead to a catastrophic structural damage of the ship or sometimes can be minor enough that the ship can continue to function. However, a thorough and detailed inspection is more than essential in such cases.

Each time, the dangers associated with ship grounding vary according to the vessel and the situation that led to the impact. In some cases, a ship grounding can lead to the vessel being stranded on the land that it contacted, leading to a difficult process to free the vessel or otherwise repair it. The damage incurred by the vessel may allow water to flood the lower part of the boat, which can be a potentially dangerous and life threatening situation. Ships can sink as a result of grounding, and loss of human life on board the vessel is possible.

One of the worst groundings was that of the containership Rena on the 5th of October 2011. The Greek Shipping Company Daina Shipping Co., a subsidiary Greek-based Costamare Inc., was the owner of the ship which was chartered by MSC (Mediterranean Shipping Company). The 47230dwt vessel was carrying 1,400 containers and about 1,700 tons of fuel. She ran aground on the Astrolabe reef 22 kilometres outside port of Tauranga in New Zealand. The hull was seriously damaged. The ship's Captain and naval officer have been charged with several offences in relation to the vessel grounding.



Map 3.2: Position of MV Rena at the time of the accident.
(Source: www.ship-disasters.com)

The mistakes that have been made have not been covered and Rena's captain and navigation officer have been jailed for seven months for allowing their ship to run aground. They both faced charges under the Maritime Transport Act 1994 for "operating a vessel in a manner likely to cause danger". Moreover, the Resource Management Act 1991 (RMA) convicted them with charges for "discharging a harmful substance from a ship" and three charges under the Crimes Act for altering ship documents [13][14]. The vessel leaked hundreds of tonnes of oil causing what New Zealand authorities describe as the worst maritime environmental disaster in their seas.

The owner company of the vessel has also faced charges under the Resource Management Act for allegedly discharging harmful substances into water [14]. The Mediterranean Shipping Company (MSC) which was the charterer of the vessel has not been charged.

[13] http://www.stuff.co.nz/national/crime/6984980/Rena-captain-and-officer-sent-to-jail

[14] http://www.safety4sea.com/charges-laid-in-relation-to-mv-rena-grounding-12741

3.2.3. COLLISIONS/CONTACTS

We can define as a collision "*the structural impact between two ships or one ship and a floating or still object such as an iceberg"* [15]. According to the Allianz Shipping Review during the last decade the number of marine accidents that collisions are to blame for, has been reduced and surprisingly in 2013 only one accident of that type has been reported. However, this category remains one of the most significant after the groundings and the sinking. In general, 50% percent of the collisions occur with other vessels and 50% occur with piers, locks and other infrastructures. A collision can have very serious consequences for the human life, the environment and the economy. A contact though, is described as a low-energy collision and usually causes permanent deformations of side structures (Wang et al.,2003). The damage from a contact is neither catastrophic not threatening for the human life and the environment.

A significant collision accident that occurred in 2013 was that one of the passenger ship MV Thomas Aquinas and the general cargo ship MV Sulpicio Express Siete. MV Thomas Aquinas was a passenger vessel registered in Philippines. She was 136.8m long with 22m beam and she had a service speed of 19knots. The Cargo Ship Sulpicio had also container capacity and she was as well registered in Philippines [16]. The first one was coming from Butuan City and the second was leaving Cebu. The time of the accident the MV Suplicious was about 1,2m from Cebu.

MV Thomas Aquinas was carrying 752 passengers, including children and infants, and 116 crew members. The accident occurred in the Mactan Channel. About 110 people lost their lives (Mullen,2013). The cargo ship had 36 crew members on board, but it did not sink after the collision. However, she sustained considerable damage at the bow. The passenger ship finally sunk and was about 40 years old. According to Jun Tagud, President and CEO of the 2GO group, the captain of the MV St. Thomas Aquinas told 2GO officials that the MV Sulpicio Express Siete was on the same lane as the passenger ship. The two captains were radioing each other but the captain of the MV St. Thomas Aquinas saw that the cargo ship was not changing lanes. At the last moment, the captain of the passenger ship tried to swerve to the left but the two ships still collided [17].

Maritime accidents are quite frequent in the Philippine archipelago because of tropical storms and the bad weather, badly maintained passenger boats and weakly enforced safety regulations. Moreever, one of the worst collisions of the past century was also off the Philipinnes, on the 20th of December, 1987. That was when, the ferry Donna Paz collided with the tanker MT Victor and more than 4,000 people were killed.

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[15] http://cdn-cache.worldlibrary.org/

[16] http://www.lloydslist.com/ll/sid/vessel/article427973.ece

[17] https://anc.yahoo.com/news/what-caused-the-cebu-sea-accident--164534540.html

3.2.4. FIRES/EXPLOSIONS

When a fire or an explosion occurs on board is a high- risk situation. When a ship is caught on fire there is a serious danger for the vessel herself, the crew and the surrounding environment. The level of danger is the same as if a civil or an industrial land structure was on fire. We must underline that a very usual phenomenon is that a fire can lead to an explosion and vice versa. Taking into consideration the quantities of liquid fuels, the electrical equipment, the engines, the boilers, the air-conditioning plants, the store of flammable materials and the crew accommodation areas (kitchen, crew mess, cabins, wcs) plus the loads of the cargo (solid or liquid goods and often flammable materials) the possibility that a fire or an explosion may occur is high. In passenger ships the load consists of entertainment and accommodation facilities for the passengers, and in ferries, of a large garage of motor vessels. Offshore rigs and tanker storage ships are essentially oil plants.

By the fact that the vessel is spending the most part of her life in the sea, there is the need of implementing strict principles and procedures. An Emergency Action Plan for Fires and Explosions is essential. A fire on board ship represents an extremely high-risk situation which may cause physical harm or death to passengers, and loss of the ship and considerable damage to her structure and equipment. Furthermore, when the ship is carrying mineral oils, chemical or gas products, gases will certainly escape into the atmosphere and very probably liquids and solids harmful to the environment will be split into the see. When the ship is unable to manoeuvre because of the damage it has sustained, especially in narrow waters, it may run aground so that mineral oils from the ship's fuel or the cargo are split into the sea. When the wrong rescue methods are employed, for example, the indiscriminate use of large quantities of water, the ship maybe lost as a result of instability, and not because of the fire.

There are precautions that are agreed upon and established by the International Maritime Organization (IMO) through international conventions. All the regulations have aimed to improve the standards in two respects. First of all, in passive defense, in terms of the fire proof compartmentalization of the ship, the use of fire-resistant material, improved electrical installations, fire-proof air-conditioning/ refrigeration/ ventilation plants, proper storage of combustible materials in relation to their flash point. Secondly, in the respect of active protection, in terms of fire detection and localization devices, automatic extinguishers of various types (sprinklers, sprays, and equipment using inert gas, CO_2, foam, halogenated liquids), mobile equipment for the use of the ship's firefighting squads (portable extinguishers, fire hydrants, foam extinguishers, and fire emergency training.

A recent accident due to a fire and an explosion was the one of the MSC Flaminia on 14th of July 2012. The accident occurred in the Atlantic Ocean. The German-flagged full container ship was en route back from the east coast of the United States to Europe. The ship sailed out of the port of Charleston on 8 July 2012. There were 23

crew members and two passengers on board (Federal Bureau of Maritime Casualty Investigation, 2014). In total the ship was carrying 2,876 containers of various sizes, from which 149 were full of dangerous goods. On 14 July 2012, a sample extraction smoke detection system alarm sounded on the bridge. The alarm indicated smoke in cargo hold 4. The lookout sent from the bridge to the cargo hold confirmed there was fire in the hatch. Following that, the officer on watch sounded the general alarm. After everybody was accounted for, closed-down state was established around cargo hold 4. CO2 was discharged into the affected cargo hold to fight the fire. The area around cargo hold 4 was to be cooled down later. A team of seven crew members was working in this area to make the necessary preparations when a heavy explosion occurred at 2 hours later.

What was followed, it was a rapid development of the fire. All passengers and the crew were commanded to abandon the ship. The victims of this accident were 2 crew members who died. Some crew memers were rescued and transferred on board DS Crown and the rest and the passengers were taken to the MSC Stela. All survivors disembarked from the tanker in Falmouth on 18th of July 2012 (Federal Bureau of Maritime Casualty Investigation, 2014).

3.2.5. PIRACY AND OTHER TYPES OF EVENTS

In this section, we can include any type of accident that does not fit into any of the above categories we described. So this category includes structural failure, lifeboat losses, crew members lost over board, infrastructure collapse, significant cargo loss, hull damage, machinery damage, piracy, with this list last being one of the most serious concerns of the maritime industry.

According to the IMO, "*Piracy is an act of boarding or an attempt to board a ship with the intent to commit theft of the intent or capability to use force in the furtherance of that act or the intent or capability to use force in the furtherance of that cat*"(IMO,2005) . Piracy may appear in many forms like a quick theft attempt or may involve an organized crime syndicate that seeks to hijack ships and hold the crew as hostages. It is a worldwide problem with higher concentrations in Southeast Asia and the waters between Somalia and Yemen. We must also underline that the odds of a piracy attack are greater when a ship is in port, but ships that are underway are vulnerable too (Talley, 2008). Moreover piracy as a form of an accident may lead to further catastrophes. For example, if all the crew is being held as hostages and no one is in the bridge, the vessel might be vulnerable to a collision accident. Finally, piracy actions may cause economic losses as many times a lot of money are paid to pirates from piracy acts.

3.3. ACCIDENTS IN PORTS

Of course, except from the offshore accidents that we described previously, there exist also the port accidents. Many studies have been conducted into ship accidents and risks at the sea but little attention has been paid to the risks in ports. However, the recent years, safety awareness in ports is growing more and more among local and international regulators (Talley, 2008).

Collision is the most common accident in ports, while groundings contribute to approximately one third of marine accidents around the world. The main factors which can lead to a marine accident in the port are the traffic and the port layout. These factors are often port-related and include the specifics of channel design, navigational aids configuration and tidal currents. We cannot compare marine traffic import with the open seas traffic, as there are a lot of differences. Inside a port, all vessels must keep a reasonable safe clearance distance from other ships, coastal structures, and shallow waters [18]. As we mentioned the most common accident in ports is collisions, and then contacts and groundings and that is because of the large number of ships and their movements inside the port.

Nevertheless, the globalization of the trade has led to a rapid increase in ship movements in ports. As this trade continues to grow, many ports will soon face an increasing number of ship accident-related risks like the ones observed in busiest ports nowadays. Perhaps some measures to eliminate the risk and prevent this from happening would be the control of the speed, the reallocation of the anchorage and other specific waterspaces, the advancement of Vessel Traffic Services (VTS), the vessel routing/fairway alignment/traffic separation, the provisioning of navigation aids.

[18]www.porttechnology.org

CHAPTER 4 – STATISTICS

4.1. MARINE CASUALTIES STATISTICS FOR 2013

More than 90% of global trade is estimated to be carried by sea. The safe and secure completion of each route is critical not only for the Shipping Industry, but also for the Global Economy. Now, after having described fully the types of the marine casualties, it is time to present complete statistical results from the past year (2013). *(at the time the paper was written we could not have a complete and clear statistical review for 2014)*

First of all, we take a look in the demarcation of maritime casualties in accordance to their level of severity. The results that are being shown in the below table, are about the year 2013.

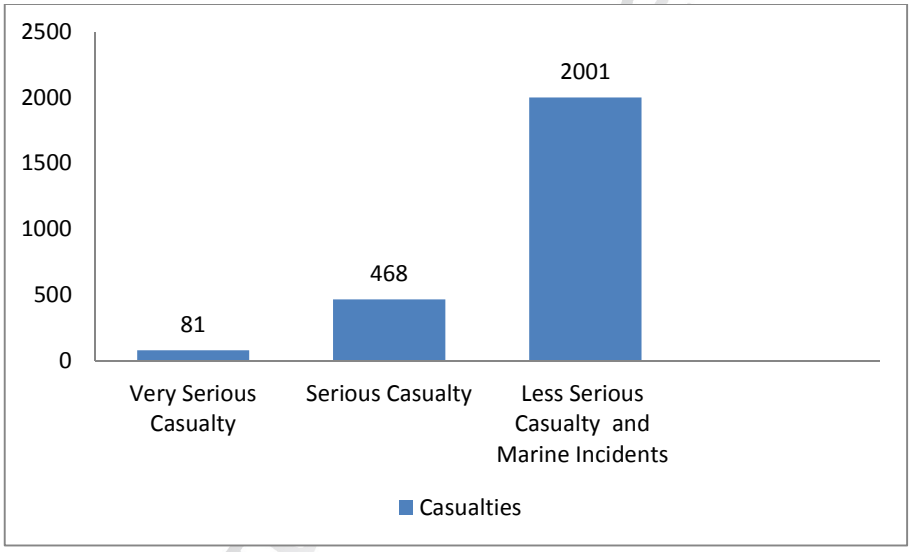

Chart 4.1: Level of severity of Marine Casualties in 2013. (Source: www.emsa.europa.eu)

In the chart above, the less serious casualties have been combined with the marine incidents. In the first category of very serious casualties are including accidents with a total loss of the vessel, loss of human life or very serious damage to the environment. As serious casualties here are included accidents of fires, collisions, groundings, heavy weather damage, that have resulted in pollution or disability for the ship. The third category is about all the other casualties that they are not considered as serious. In percentages, only 3,6% of all accidents that were reported were classified as very serious, 18,1% were serious and 78,3% were less serious and marine incidents. The total number of marine occurrences (both marine accidents and incidents) in 2013 was 2.550 and the average number of accidents per month was 212.

The total number of ships involved in the marine casualties during 2013 was 2.872. The total large vessels' losses that were reported during the past year were 94. This number represents a significant reduction, as the annual total dropped under 100 for the second time in 12 years. Moreover, in comparison to 2012 where the total losses reached 117, we have a 20% decrease and throughout the last ten years, that means from 2003, the shipping losses have declined by 45%. The graph below represents this declining trend.

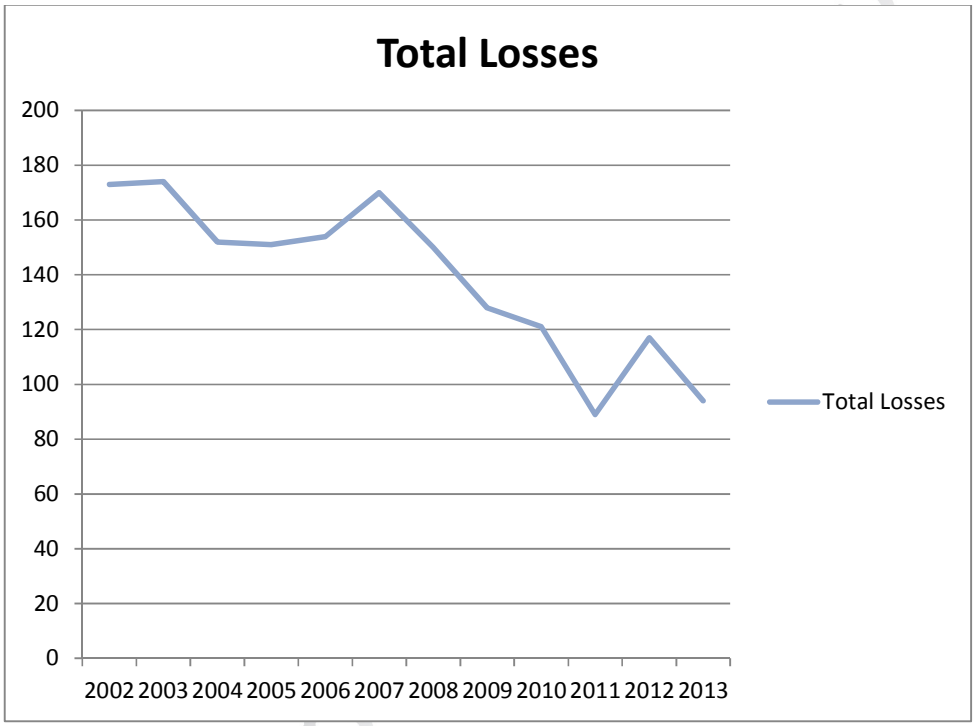

Chart 4.2: Total Losses by Year [2002-2013] (Source: www.agmc.allianz.com)

The reduction that is presented above is a proof that the attempts that have been made in order to prevent the occurrence of a marine accident have given back. Every year more lessons are learned from the previous casualties and more safety measures are taken in technological and organizational level. The aim is to keep this trend to a declining direction.

So, the International Maritime Organization (IMO) continued to focus on the improvement of the safety legislation. A number of recommendations and amendments to safety related regulations were discussed. The discussions gave also attention to the passenger vessels, especially after the Costa Concordia disaster. The amendments were concerning among others, to the SOLAS regulation III/19 (for the emergency training to mandate enclosed-space entry and rescue drills), to the International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code) and the IMO Instruments Implementation Code (III Code,

which provides a global standard to enable states to meet their obligations as flag, port and/or coastal states, the framework and procedures for the IMO Member State Audit Scheme, the 2013 non-exhaustive list of obligations under instruments relevant to the III Code and a resolution on transitional arrangements from the voluntary to the mandatory scheme (Safety and Shipping Review, 2014).

Continuing the statistical overview of the last year, we examine the regional distribution of the accidents. South China, Indo China, Indonesia and the Philippines were the regions with the most losses (in total 18). According to the Lloyd's List Intelligence Casualty Statistics, for the 94 total vessel's losses we have the below regional distribution:

- South China, Indo China, Indonesia and the Philippines: 18
- Japan, Korea and North China: 17
- East Mediterranean and Black Sea: 9
- West African Coast: 8
- Arabian Gulf: 6
- Bay of Bengal: 5
- East African Coast: 4
- British Isles, N. Sea, Eng. Channel, Bay of Biscay: 3
- Canadian Arctic and Alaska: 3
- West Mediterranean:3
- Others: 18

In the following map we are presenting the total losses of large and passenger vessels showing location of loss and type of vessel. The time period is from January 1st 2013 to December 31st 2013. We have highlighted the 10 largest losses by ship type and all passenger losses.

Map 4.1: Marks show the location of total losses. [Jan 1st – Dec 31st 2013] (Source: www.agmc.allianz.com)

We are listing below the report of each highlighted casualty for the largest ships:

1. **MOL Comfort (86,692GT)** : 17/06/2013, Broke in two after sustaining a major midship crack and it sunk. No fatalities were reported.
2. **Frotamerica (22,174GT)** : 21/02/2013, Grounded after drifting from anchorage, but no fatalities.
3. **Smart (77,240GT)** : 19/08/2013, Grounded, buckled, broke in two, partly submerged, but no fatalities.
4. **Branded (18,334GT)** : 15/07/2013, Fire on board and the vessel was after that sent for scrapping. No fatalities were reported.
5. **Trans Summer (33,044GT)** : 14/08/2013, Sank in typhoon, but without any fatalities.
6. **Setubal Express (16,295GT)** : 07/02/2013, Fire on board, but no fatalities.
7. **Fu Sheng Hai (31,643GT)** : 02/07/2013, Grounded and broke into two. Forepart sank with no fatalities.
8. **Kiani Satu (16,660GT)** : 07/08/2013, Grounded in bad weather and sunk. No fatalities.
9. **Harita Bauxite (30,228GT)** : 17/02/2013, Sank after engine problems in heavy weather. 15 fatalities were reported.
10. **Atlantik Confidence (16,252GT)** : 30/03/2013, Fire/explosion on board. The vessel sunk.

And now for the passenger vessels :

1. **Setubal Express (16,925GT)** : 07/02/2013, Fire on board with no fatalities.
2. **Fajar Samudera (2,165GT)** : 23/02/2013, Sank following water ingress. No fatalities were reported.
3. **Massimo M (12,494GT)** : 19/06/2013, Fire on board. The vessel was sent for scrapping. No fatalities.
4. **GP Ferry 2 (2,072GT)** : 14/06/2013, Sank in heavy seas, but no fatalities.
5. **St Thomas of Aquinas (11,405GT)** : 16/08/2013, Sank following collision with Sulpicio Express. At least 116 fatalities were reported.
6. **Baleno 168 (989GT) :** 31/01/2013, Stranded after losing propeller. Sank with no fatalities.
7. **Spirit of Fiji Islands (4,421GT)** : 12/10/2013, Fire on board and drifted. Crew abandoned and rescued. No fatalities.
8. **Theodoros Maria Z (479GT)** : 06/07/2013, Capsized and sank. Only 1 fatality was imported.

(Source: www.agmc.allianz.com)

As we mentioned in a previous section, we categorize the marine casualties by the type of the vessel and by the type of the event. We are listing below a statistical chart with number of marine accidents by vessel type for the last 12 years (2002-2013). In total we had 1.673 losses.

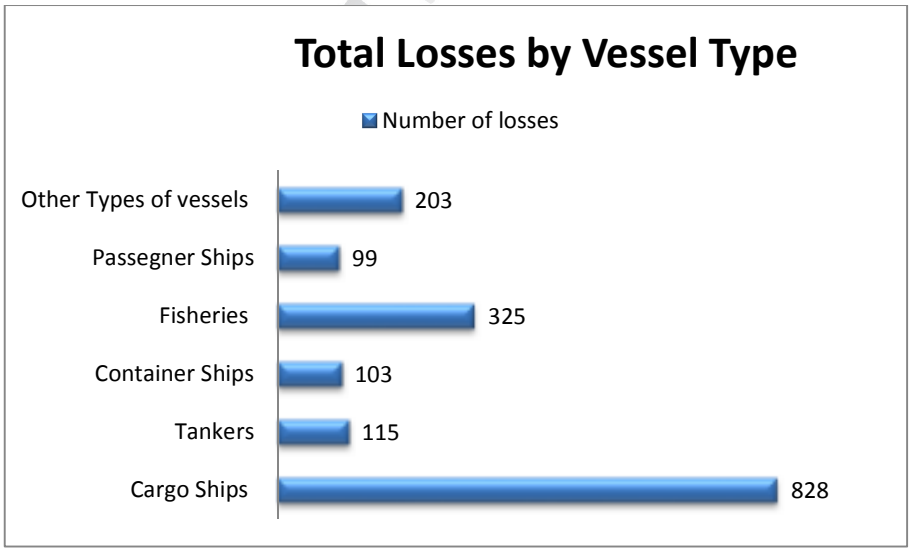

Chart 4.3 : Total Losses by Vessel Type 2002-2013
(Source: www.agmc.allianz.com)

Especially for the past year (2013), we had :

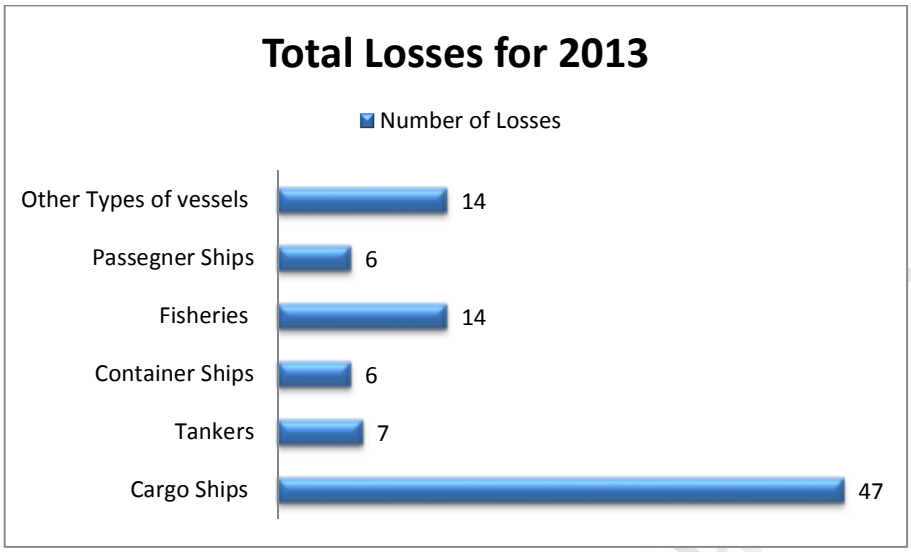

Chart 4.4 : Total Losses for the year 2013
(Source: www.agmc.allianz.com)

As we can deduce from the two above bar charts, the cargo ships are the most common vessel type to be involved in marine accidents. This fact arises questions about how secure is the storage of the cargo and if the loading limits are passed or not. Second come the fisheries, where main reasons like crew fatigue, presence of dangerous machinery, failure to provide protective equipment result to the above numbers. Tankers, container ships and passenger ships come next in line.

Now we will present the statistics of total losses of the vessels by the type of the event. The first pie shows the numbers from the last 12 years (2002-2013).

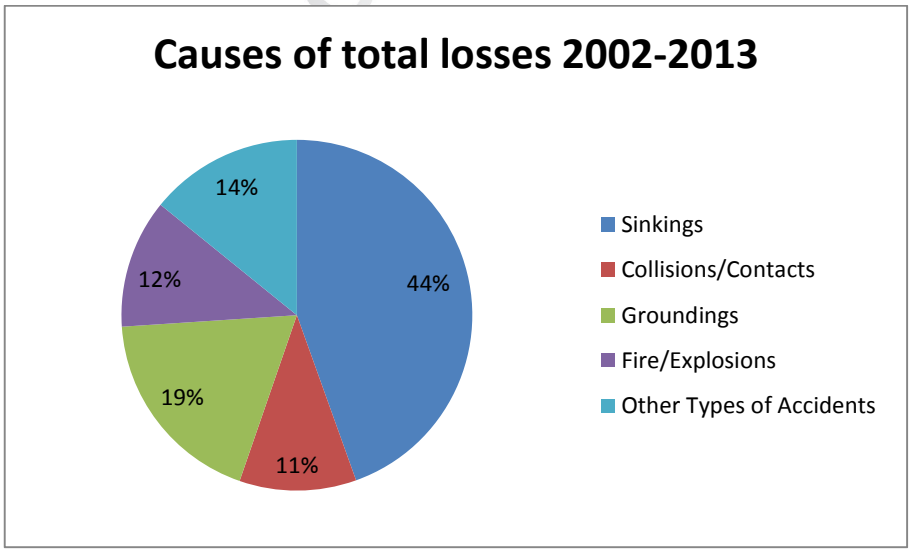

Chart 4.5: Causes of total losses 2002-2013 (Source: www.agmc.allianz.com)

The second pie shows the statistical percentages for the last year 2013. As we have mentioned before the total losses last year were 94.

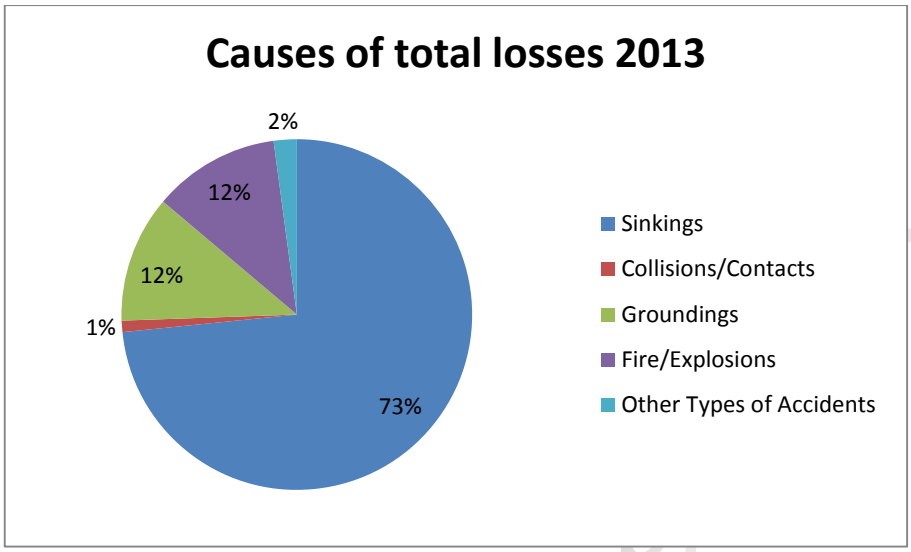

Chart 4.6: Causes of total losses for the year 2013 (Source: www.agmc.allianz.com)

As we can see, the biggest percentage is a courtesy of the sinkings. Groundings and fires/explosions come to the second place, while the collisions in the third place. Not only for the last year, but also for the all years in the past decade! 2% of the category "Other Types of Accidents" refers to two in number losses of vessels. Both were caused by machinery damage/failure.

CHAPTER 5 – CAUSES AND RESULTS

5.1. CAUSES OF MARINE CASUALTIES

There are many factors that can result in an accident at sea. Some are caused by an inexperienced captain and crew, while others result from unfavorable conditions (natural conditions, technical failures, route conditions, ship-related and cargo-related factors). We analyze below the major of these factors, with the main one being the Human Factor.

5.1.1. HUMAN FACTOR

Throughout the years in the shipping industry, we have seen improvements in hull design, stability systems, propulsion systems and navigational systems [19]. Despite the fact that nowadays ship systems are technologically advanced and highly reliable, the maritime casualty rate is still high. Of course, no technological system is unmistakable, but the maritime system is a people's system, and human errors are primarily mover in casualty situations (Berg, 2013). So, the human factor has a fundamental importance in the rate that maritime accidents occur. Research and statistics show that human error is to blame in over 70% of marine accidents (about 75-96%).

By "human error" we mean an incorrect decision, an improperly performed action, or an improper lack of action (Rothblum, 2002). The types of human errors that contribute to the occurrence of a maritime incident or accident are innumerable. In many cases an accident is caused by trips and falls, fire, pollution and collisions, low capability and reaction of the crew, lack of communication, lack of implementation of safety practices and regulations, inadequate training, failure in the rational judgment of the situation. Such incidents often result in crew injuries or fatalities, with the ship being consequently delayed or damaged (Anyanwu, 2014). Some other forms by which the human factor is to blame for marine accidents are technical inability, carelessness in commanding, fatigue and lack of alertness, overworking, unsufficient rest periods and so forth.

[19]www.ship-technology.com

Usually, a marine casualty is occurred not only because of one reason or a single mistake, but by the confluence of a whole series or chain of errors (Rothblum,2002). There are many cases were more than one human errors were made, each of which was a necessary condition that led to the casualty. This also means that many of the serious accidents reviewed might have been averted if some of the above deficiencies did not exist. Therefore, in order to achieve greater marine safety and fewer casualties, we must find ways to prevent some of the most usual errors or at least increase the probability that such errors are noticed and corrected in time. Below we are listing some of the most common factors that can affect the performance of a ship's crew and therefore lead to an undesirable situation:

- The energy storage that each employee may have
- The fatigue of each working date in accordance to the free time he has for rest
- The satisfaction someone gets from his job
- The living conditions on board
- The differ demands of the job
- The qualifications and the knowledge of each seafarer
- The basic and continuous training
- The ability to communicate easily with his colleagues and to encourage the team work and the trustworthiness.

Taking into consideration the above factors and that the Maritime System is a people's system, addressing the human side of shipping must be the most effective approach for increasing safety. People are those who interact with the technology, the environment and the organizational factors (Rothblum, 2002). Hence, in one hand there is the how people act inside their working environment and on the other hand there is the how the technological, environmental and organizational factors affect the way people perform in it.

First of all, we must think of the people themselves. In the maritime system when we say people this include the ship's crew, the captain, the dock workers, the shore crew, the Vessel Traffic Server operators and others. It very important to choose wisely who to put in every job position, in order to secure the safe and well going operation of the maritime system. Of course, human beings have certain abilities and limitations and they are not machines. Human performance is influenced by the knowledge, the skills, the abilities, the memory, the motivation and the alertness (Rothblum, 2002). For the IMO and for all the organizations that are focusing on the safety at sea, the secure crewing of the ships is one of the most important tasks. The experience and the qualifications of the seafarers are very essential characteristics for their recruitment. Furthermore, the number of the seafarers plays a significant role for the safety of the ship, the crew, the passengers, the cargo and the protection of the environment. We must focus on the good training and expertise of the marine employees (on board ships and ashore) in order to improve the way that they response to an urgent event or situation. The proper education and training of the ship's personnel constitutes one of the most important risk reduction measures. The crew must have the appropriate

knowledge of safety rules that need to be followed, of the ship's systems and of course good general technical knowledge. Taking into consideration the above, we can summarize the three main sectors of knowledge for a seafarer to the following 3 categories:

- Knowledge of Safety Regulations: The IMO has continuously dealt with safety problems and the improvement of safety at sea has been highly emphasized. All the international safety-related marine regulations are guided by lessons learned from serious marine accidents. IMO has developed a safety culture at all levels of the industry's infrastructure, from company managers to vessel operators (Wang et al., 2005). The goal is to reach a level of proper and reliable implementation of the all the safety rules and regulations.

- Knowledge of ship's Systems: A frequent contributing factor to marine casualties is inadequate knowledge of own ship operations and equipment (Rothblum, 2002). There are occasions where a captain or crew members change continuously their working environment. As a result, they are working on board different sizes of ships, different types, they handle different technological equipment. It is an undisputable fact that this kind based of recruitment can yield difficulties. A combination of better training, standardized equipment design, and an overhaul of the present method of assigning crew to ships can help solve this problem (Rothlum, 2002).

- General Technical Knowledge: The main contributor to this category was a lack of knowledge of the proper use of technology, such as radar. Mariners often do not understand how the automation works or under what set of operating conditions it was designed to work effectively (Rothblum, 2006). The unfortunate result is that the crew sometimes makes errors in using the equipment or depend on a piece of equipment when they should be getting information from alternate sources. So, even when there has been a mechanical failure, human error can play a role either by way of a lack of maintenance or monitoring (failing to pick up a potential problem), a lack of suitable equipment or protective devices, or a breakdown in communication or procedures [20].

[20]http://www.standard-club.com/news

Furthermore, it is often a matter of fact that the blame often goes to people working on the stages before any ship starts travelling. Hence, ignorance of the engineering factors that cause human error is due primarily to a lack of knowledge and guidance at the design, building and operation stages (Paik, 2012). To eliminate the human error more extensive knowledge must be applied to all the above stages. A key part of this more extensive knowledge is made up of lessons learned from past accidents with a focus on structural design and engineering. Here we will present a very popular example to explain the importance of the correct shipbuilding. One of the most notorious accidents in the Maritime history was the one of Titanic on April 15, 1912. According to Paik (2012) this accident has to offer several lessons from the structural design viewpoint. First, steel tends to become brittle at low temperatures. Even modern steel products provide no exception to this rule and it is suspected that those used in the Titanic structure had unsufficient fracture toughness to withstand low temperature (Askeland et al., 2010). In other words, the vessel's hull structure was prone to brittle failure in the face of local impacts. Secondly, the impact velocity at the time of Titanic's collision with the iceberg is reported to have been 23 knots, which is likely to have caused a large amount of initial kinetic energy, and subsequently to have created large holes that allowed a significant amount of water to enter the ship (Paik, 2012). Third, accidental flooding most likely altered the hull girder load distribution and amplified the maximum hull girder bending moments. Fourth, because the water ingress following the collision with the iceberg subjected the ship to sagging moment in the boiler room, the large axial compressive loads bearing on the deck structures led to their buckling and collapse. It is clear that ultimate limit state design methods that consider buckling and plastic collapse should be applied in the design of ship structures in order to prevent hull breakage [21].

As we mentioned above the technological, environmental and organizational factors with which people interact play also a very significant role the maritime accidents' problem. The design of technology can have a big impact on how people perform. For example, people come in certain sizes and have limited strength. So when a piece of equipment meant to be used outside is designed with data entry keys that are too small and too close together to be operated by a gloved hand, or if a cutoff valve is positioned out of easy reach, these designs will have a detrimental effect on performance (Rothblum, 2002). Automation is often designed without much thought to the information that the user needs to access. Critical information is sometimes either not displayed at all or else displayed in a manner which is not easy to interpret. Such designs can lead to inadequate comprehension of the state of the system and to poor decision making (Rothblum, 2002).

[21]www.sname.org/sname/mt

Furthermore, the environment can also affect the humans' performance. In the environment sector are including the weather and other aspects of the physical work environment (such as lighting, noise, and temperature), but also the regulatory and economic climates. The physical work environment directly affects one's ability to perform. For example, the human body performs best in a fairly restricted temperature range. Performance will be degraded at temperatures outside that range, and fail altogether in extreme temperatures (Rothblum, 2002).

Finally, organizational factors can affect human performance. When we are referring to organizational factors we mean both the crew organization and the company policies. Crew size and training decisions directly affect crew workload and their capabilities to perform safely and effectively. A strict hierarchical command structure can inhibit effective teamwork, whereas free, interactive communications can enhance it (Rothblum, 2002). Also, we must note the importance of good communication and coordination on and between vessels (Berg, 2013). Furthermore, crew fatigue and complacency can often be a major factor in incidents. The prudent ship-owner or manager will ensure that these are addressed by way of additional manning or rotating the ship staff more regularly if the ship is employed on a demanding trade route (Rothblum, 2002). Good equipment can cost more, but safety should be accorded a higher priority, because a ship cannot be operated safely without the seafarer. Lastly, company policies with respect to meeting schedules and working safely will directly influence the degree of risk-taking behavior and operational safety [20].

All of the above factors can affect positively or negatively the performance of a seafarer, and this can have direct results in the right operation of the ship. We must underline that a ship is a small community that need to operate peacefully and collaboratively. According to the IMO the safe crewing of the ship must be based in some principles. Below are listed some of these principles:

- The capability to maintain safe navigational, engineering and radio watches and maintain general surveillance of the ship
- The capability to moor and unmoor the ship safely
- The capability to manage the safety functions of a ship when employed on a stationary or a non-stationary mode at sea
- The capability to perform operations for the prevention of damage to the marine environment
- The capability to maintain the safety arrangements and the cleanliness of all accessible spaces to minimize the risk of fire
- The capability to provide for medical care on board ship
- The capability to ensure safe carriage of cargo during transit
- The capability to inspect and maintain the structural integrity of the ship
- The ability to operate all watertight closing arrangements and maintain them in effective condition
- The ability to operate all on board fire-fighting and emergency equipment and life-saving appliances

- The ability to operate the main propulsion and auxiliary machinery and maintain them in a safe condition to enable the ship to overcome the foreseeable perils of the voyage.

Unless human error can be minimized, it is not possible to protect human health and the environment fully and to ensure safety. In order to reduce the blame of the human factor in the cause of marine accidents, it is very important to take some measures. There is the need of better knowledge and expertise guidelines from the Administration or the Management Company of the ship. The good communication between the seafarers and the offshore stuff is also very important. Above all, the detailed manning arrangements should ensure a degree of safety at least equivalent with the current guidelines. The focus must be on the selection of the crew and its continuous training. Many times the maintenance of the knowledge is much important than the basic one. The implementation of that seamanship is essential, as there is always the risk of the danger.

From all the above, we conclude to the fact that the human error is inevitable. The reduce of the marine accidents and the decrease of their results can be better achieved by learning from past mistakes. We must continue to study the human factor as it can be from the main reason to an effective tool for avoiding accidents.

5.1.2. AGE AND DESIGN OF THE SHIP

The age of the ship is one parameter that adversely affects the security of the ships. The truth is that younger ships suffer highest accidents rates. However, despite the age of the ship, its good or bad maintenance and the quality of the refits and repairs play a very significant role. The good maintenance and the regular surveys are essential. The poor maintenance can result in a breakdown during critical conditions.

In the modern world of shipbuilding the ship designers usually incorporate the suggestions of seafarers who are familiar with or have sailed on the type of ship that is being designed. Proper supervision during the building process ensures that discrepancies and potential problem areas can be addressed. Senior officers are also able to join the ship during the final fitting-out process in order to familiarize themselves with the ship and, especially, the increasingly complex equipment they will be required to use [20]. The maritime sector has devoted substantial effort to applying advanced design approaches. By the twentieth century many of the principles of modern-day ship design were well established. Hull and structure design, but also innovations on the bridge have been drastically improved over the past years. Technological improvement and computer development (modeling, simulation and analysis programs) have replaced lengthy and laborious calculations on stability, structures and hydrodynamics. Day by day, more and more safety precautions are noticed, and as a result the ship design can be modified and adapted in order to reduce the risk or to develop technological systems which will do the same.

5.1.3. EXTERNAL FACTORS – NATURAL CONDITIONS

There are times when no human or mechanical situation are to blame for a marine accident. Natural conditions could be natural phenomena as current, tide and tidal stream, strong winds, reduced visibility (fog, heavy snow or rain), storm seas, darkness etc. affecting the ship or the ones who control her. Heavy weather conditions can cause serious damage to the hull of the vessel or the sinking of it or loss of the human life. Bad weather is a constant hazard at sea and that is why ships are built to withstand it [22].

Due to the unpredictable and dangerous characteristic of the natural conditions, it is essential to conduct quite often good seamanship practices and forward planning for facing such unexpected situations. The Captain and the crew must be fully aware of the natural conditions of the sea that they are going to sail into. With particular attention to seasonal tidal changes, the weather in monitored by the bridge and all information should be passed onto the relevant persons to assure they are fully aware of the weather conditions. Also, shipping forecasts are broadcast to warn the seafarers of what conditions they should expect. The best route for a ship is always developed taking into consideration the existing weather forecasts. The goal is not to avoid all adverse weather but to find the best balance to avoid placing the vessel at risk or causing crew injury [23].

Even though if there is a practice of sending pre weather warning to ships for route change or speed alterations, nature is bound to show ups and downs, and heavy weather may hit a vessel in open sea with no time to react. Time is a very critical factor in an urgent situation like this, and any crew member on board ships must to know how to behave and what to do in order to avoid any mistakes. According to the Marine Insight (The Ultimate Guide for Personal Safety on Ships, 2012), there are some basic precautions to be taken when in rough weather, and we are listing them below:

"*Steering control*

- *In open sea, vessel is normally in auto pilot. It is advisable to change over to hand or manual control to avoid excessive hunting of the rudder.*
- *One person should go and check all the oil levels, linkages and other important parameters of the steering gear in the steering room.*
- *If one motor is running, switch on other motor and run both of them together to get maximum available torque to turn the rudder.*
- *Sufficient man power including senior officers to be present in the bridge.*

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[22]http://www.plimsoll.org

[23]http://www.acmg.allianz.com: "Safety and Shipping 1912-2012".

Machinery control

- *If engine room is on UMS mode, man the engine room and make sure sufficient man power is available.*
- *Monitoring all the parameters of the main propulsion plant and auxiliary power plant machineries.*
- *After getting rough weather warning, all the spares in the engine room are to be stowed and lashed properly.*
- *In bad weather, propeller will come in and out of water and will fluctuate the main engine load. Hence rpm is to be reduced or main engine control setting is to be put on rough weather mode.*
- *Always make sure for correct sump level of all the machineries as during rough sea ship will roll, resulting in false level alarm which can even trip the running machine and lead to dangerous situation in bad weather.*
- *Level of all the important tanks is to be maintained so that pump inlet should not loose suction at any time.*
- *Stand by generator is to be kept on load until the bad weather situation stops.*
- *Watertight doors in the machinery spaces to be closed.*
- *Sky light and other opening to be closed.*
- *All trays are to be avoided from spilling in event of rough weather*

Other common precautions

- *It is to be instructed to the crew not to go out on open deck in rough weather.*
- *All the deck items like mooring ropes, lashing equipment, drums etc. to be stored and lashed properly after their use.*
- *All openings in the deck for cargo and other spaces to be kept shut.*
- *All opening to the accommodation to be kept shut.*
- *Shaft tunnel and other internal access space are to be used to go to steering room or other compartment.*
- *Everyone must be aware of his/her duties pasted in the muster list.*
- *Elevator to be switched off as during rolling and pitching trip may occur and can cause trapping of the person inside.*
- *Always wear all the PPE'sand use railings and other support while walking through any part of the ship to avoid trips and fall.*
- *Be alert and work in team."*

5.1.4. OPERATING STANDARDS -MECHANICAL FAILURE

There have been attempts to avoid a percentage of the occurrence of the marine accidents by improving the methodology of the design of the ships. However, this has not been proved very effective as there is still the need by the seafarer to understand and learn the operating manuals of the new equipment. A research that has been made by the Confidential Hazardous Incident Reporting Program (CHIRP) and in

cooperation with UK's Marine Accident Investigation Board, has shown that a substantial number of accidents are caused by operating manuals that are hard to understand. For instance, the manual is sometimes written in a language that is not understood by the entire crew [20].

Furthermore, mechanical failures, like engines breakdown, have become quite a common cause for marine accidents those days. The failure of the machinery can be a result of water in the fuel or a fuel pump failing for example, or a short-circuit which may lead to a fire.

Another element that we can include to this category is the navigational equipment. Nowadays, radars and satellite navigation systems are essential for any seafarer and also more reliable than any other older methods of navigation. However, there is always the possibility that an electronic device can go wrong. This can result to a very dangerous fact, as the position of the ship at that time will be uncertain (and especially in bad weather conditions). Navigational errors include over reliance on inaccurate nautical charts, charts of suspect reliability or leading to narrow channels. However, during the 20th century the Global Positioning System, known as GPS, has revolutionized the navigation across the world. GPS can give to the navigators a range of information that is critical to safe passage and it is not depending on the weather or the location [23].

5.1.5. LACK OF UNIFIED STANDARDS

A seafarer must be provided with a safe environment to live and work but also with the proper guidelines. A unified standard for basic equipment is essential for any vessel. The lack of oily water separators, voyage data recorders and lifeboat launching equipment can conclude to disappointed results [20]. If a vessel is equipped fully and properly we can prevent serious damages and the loss of human life as well. For example, we are listing below the essential equipment of a modern passenger vessel according to Paul Newton, Head of Hull and Liability on AGMC

- Voyage Data Recorder, Radar and DGPS precision position finding
- Emergency Position Indicating Radio Beacon (EPIRB)
- Communications by Satellite, VHF and GMDSS
- Mandatory Passenger Information System
- Mandatory crew training in emergency procedures and safety drills within 24hours of sailing
- Welded construction
- Enclosed life boats and rafts (to accommodate all persons on board plus spare capacity)
- Up to date weather forecasts, including Hurricane tracks, iceberg locations and their drift patterns and severe storm warnings
- Compartmentalized construction including fire containment
- Navigational aids (including Echo sounder, AIS, ECDIS and Radar)
- Helicopter rescue and long range casualty evacuation services
- Emergency immersion suits for all passengers
- Bridge designed for all round visibility.

5.2. PERCENTAGES

To present the above in numbers, we can see below the percentages of each cause in the occurrence of a marine casualty:

1. Human Factor 70-90%
2. Age and design of the ship 8-15%
3. Lack of Unified Standards 6-10%
4. Operating Standards – Mechanical Failures 4-7%
5. External Factors 2-5%
6. Unknown cause 2-5%

Below we analyze further the 70-90% of the human factor. So we have:

1. 25-30% fault of the Chief Mate
2. 2-5% fault of the Chief Engineer
3. 16-20% fault of the Crew
4. 10-15% fault of the Shore
5. 7-10% fault of the Pilot

Finally, studies have shown that human error contributes to (Rothblum, 2002):

1. 84-88% of tanker accidents
2. 79% of towing vessel groundings
3. 89-96% of collisions
4. 75% of strikings/contacts (allisions)
5. 75% of fires and explosions

5.3. THE IMPACT OF THE MARITIME ACCIDENTS

As we have seen the range of the maritime accidents is very big and the different types are numerous. Each time that a maritime accident occurs, it has its own unique characteristics and series of reasons that lead to a result. "Victims" of the marine casualties can be not only the humans but also the marine environment and ecosystem, the economy, and the society as whole.

Generally, in regards to the economic impact of the maritime accidents, we must note that there are two types of costs, the direct costs and the indirect costs. The direct costs are concerning the money that is given by the company to cover the critical results of an accident. In this category are including the property and equipment damage, worker's compensation payments resulting from the injuries, clean-up costs, lost income resulting from operation delays and so on. The direct costs are easy to be measured, unlike the indirect ones. In this second category are including productivity losses, costs of management, impacts of public image and employee morale and so on. Furthermore, the cost of a maritime accident differs in regards to the type of it. Hence we have oil spill costs resulting usually from tankers' accidents, property damage costs, injuries and deaths cost and all the indirect costs and the insurances.

Oil spillage is greater for collision and material/equipment failure accidents (Talley, 2008). Whether small or large the oil spill is, it can be very expensive. This happens why the oil spill leads to emergency response and clean-up costs, environmental damages, third-party damages, loss of cargo and others.

Property damage costs are referring to the loss of the equipment. They usually are a result of collisions, groundings, fires and explosions. They are ranging from minor losses to total construction damages. Of course, a total loss is greatest for a capsizing, followed by a sinking accident. The damage costs are usually connected to the hull insurance rates.

In regards to the crew/passengers deaths and injuries we have the medical expenses like doctor fees, hospital charges, compensations, costs of medicines, future medical costs. Accident injury severity is most common in passenger and crew ships, where unfortunately we have more victims.

Concerning the environmental impact of the maritime accidents, it is a matter of fact that they seriously affect the marine ecosystem and the sea creatures. Especially, the results of oil spills from tankers can be catastrophic. Each year thousands of tons of oil and fuel are trading by the sea. The risk of a serious accident is always big. The accidents that usually result to the pollution of the environment are sinkings,

groundings, collisions, fires and explosions, war loss (especially if commercial ships are being involved in such incidents) and structural failures.

PART II

CHAPTER 6 - CASE STUDY 1

6.1 MV SEOWL

Image 6.1: MV Sewol (Source: www.marinetraffic.com)

Type of the vessel: Ro –Ro/ Passenger ship

Type of the event: Sinking

Date: 16th of April 2014

Time: Around 9.00am to 11.30am.

Location: 1,5 kilometers (0.93mi) off Donggeochado, Jindo County, South Jeolla Province, South Korea
Coordinates 34°13′5″N 125°57′0″E

Deaths

294 on board

1 navy sailor

2 civilian divers

5 emergency workers

On board in total 476

Survivors 172 (171 excluding the subsequent suicide of the vice principal of Danwon High School)

(Source of data: www.cruiseshipsinking.com)

6.2 THE VESSEL MV SEWOL

"On the foggy evening of April 15, 476 passengers, most of them high-school students, boarded the ferry MV Sewol in Incheon, South Korea's third largest city, headed towards the holiday island of Jeju. Eleven hours later, what should have been a routine trip had become one of the worst disasters in Korean History: after the ferry capsized and calls for help were not answered in time, more than 300 people died, many of them 16 year olds." (Fan, 2014)

The vessel was built in Japan (Hayashikane Dockyard, Nagasaki) in June 1994 for Marue Ferry and she was named Ferry Naminoue during the time of operation and the purchase. She was launched in lines of Okinawa for the next 18 years, until October 2012 when she was sold to the South Korean Chonghaehjin Marine Co. based in Incheon for 11.6 billion (9.8$ million).. Under the name Ferry Naminoue, she had a total capacity of 6.586 grt, 146m length, 22 m beam and 6,26m draught. She had 2 main engines United Pielstick 12PC2 – 6V – 400 (15.974 bhp) and was developing a service speed of 19,5 knots. The ship could carry on 804 passengers, 90 cars, 60 trucks and 152 containers of 20 feet in a special shaped space in the bow. She had stabilizer fins, fixed pitch propellers, double rudders and bow-stern thrusters.

Before the beginning of the route in the water line Incheon – Jeju, since December 2012 to February 2013, she was refurbished in the bow. The decks No 3,4 and 5 were extended in order for more cabins to be added. The passengers'protocol increased by 117 passengers (total 921). The ship which had now a total capacity of 6.825 grt, passed the controls of the Korean Register of Shipping (KRS), after a 5 month testing period, and in 15th of March 2013 started the itineraries as the Register approved the modifications made. Until the day of the accident, the vessel had travelled the same route about 241 times. After the modification the vessel had a legal capacity of 956 people, including the crew, 180 vehicles and 154 regular cargo containers. She weighted as we mention 6,825 tons, and had 46 rubber lifeboats, each of a capacity of 45. Sewol could travel at a maximum of 22 knots (41km/h) [24].The ship performed two to three round trips per week, from Incheon to Jeju. Each trip was of 400 kilometers (250mi) distance voyage and it was taking 13,5 hours to reach the final destination. Moreover, the vessel had passed successfully the Safety Inspection (in 200 points) which was conducted by the Korean Shipping Association in February 19 2014 [25]. A second inspection followed in order to secure that the ship was in a situation sufficient for the demands of the KRS (Korean Registry of Shipping. The vessel passed also that second inspection successfully. However, the Register decreases the cargo capacity of the vessel by half to 987 tons and required 2,000 tons of water to serve as ballast in order to provide balance. The South Korea government's Audit and Inspection Board later revealed that the Register's licensing was based on falsified documents. Prosecutors later estimated that 1,076 tons of cargo

were permissible and that 1,695 tons of ballast were necessary to carry 1,077 tons of cargo [24].

In the table below, we provide full details for MV Sewol.

IMO: 9105205	**Gross Tonnage:** 6.586
MMSI: 440000400	**Dead Weight:** 3.981 t.
Call Sign: 121832	**Length x Breadth :** 145,61m. x 22m.
Flag: Korea (KR)	**Year Built:** 1994
AIS Type: Passenger	

Table 6.1: MV Sewol (Source: www.marinetraffic.com)

[24]http://www.wikipedia.com

[25]http://www.maritime-economies.gr

6.3 THE ACCIDENT

TIMELINE OF THE EVENTS

In the next lines, we are presenting a timeline of the events that occurred the day of the accident, taking into consideration information from the media:

15 April 2014, 21.00

MV Sewol should have set sail on its regular overnight journey from Incheon to the volcanic island of Jeju (a popular touristic attraction of the country) at 18:30 on the evening of 15 April [26]. The departure delayed for 2,5 hours due to the fog and eventually the ship departed at 21.00. The trip was about to last for 13,5 hours approximately.

The ship was often covering the 264 nautical miles of that water line by a service speed of 16 knots. According to the Korean Ministry of National Security and Public Management, 459 passengers were on board : 325 students of Danwon high school (the students were about to start a 4 day excursion), 15 professors, 89 other passengers and 30 crew members. However, according to the manifest the total number of passengers was 476 and maybe higher. Moreover, in the garage of the ship, the Korean Shipping Association had recorded 150 cars and 657 tons of cargo.

The ship was commanded by 69-year old Captain Lee Joon-seok, a substitute captain who was brought in as a replacement for the regular one (Kwaak, 2014). He was hired on an one year contract with a monthly payment of □2,7 million. Lee was usually working with 33 crew members, 19 of which were irregular, part time workers [24].

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[26]http://www.bbc.co.uk

Map 6.1: MV Sewol Route (Source: www.bbc.com)

16 April 2014, Morning

By the morning the ship was sailing through a treacherous area of water near Jindo island when it made a sharp turn and began to list severely. It is not clear why this sudden turn has been made, but Captain Lee Joon-seok was not on the bridge at the time and an inexperienced third mate, Park Han-kyul was navigating [27]. Automatic Identification System data released later by authorities, showed that as the ferry turned, it lost control and began drifting sideways [26]. Right after that a water inflow followed and the ship began heeling to the left, approximately 16 nautical miles off the southwest shore of the Korean peninsula. The time of the incident the weather conditions at the sea were perfect. There was no wind, while in the region where the ship was sailing, there were no rocks or reefs.

16 April 2014, 08:52 am

As the ship was leaning over, the first distress call came not from the crew but from one of the students, a teenage boy who dialed the national emergency number [28]. "Save us! We're on a ship and I think it's sinking," the boy told the fire officer on land (Jeollanam-do fire station) who took the call. Boy's name was Choi Duk-ha. Choi was connected to the Mokpo Coast Guard 2 minutes later and was asked to give the coordinates (latitude and longitude) of the ship's location [24]. Three minutes later, at 08.57am, the Mokpo Coast Guard Station situation room, ordered patrol vessel No. 123 to be dispatched to the scene. The vessel was launched on 8.58am [26].

[27]http://www.theguardian.com

[28] http://www-cgi.cnn.com

Following the Coast Guard search and rescue manual, the boat was to be in charge of surveying the area and "swiftly" rescuing passengers. According to references, Choi, the college student, unfortunately did not survive the capsizing and was later found dead.

As the Sewol began sinking, a communication officer, Kang Hae-seong, started to make announcements from the ferry's intercom system ordering the passengers to stay put as moving was dangerous. The announcements began at least at 08.52 am. Unfortunately, neither the other crew members nor the Captain changed the command even if the water had already began to flood the vessel.

16 April 2014, 8.55am

At 8:55, the crew called for help, contacting Jeju Harbour Affairs. In the communication with the VTS, the ship asked for help. Transcripts reveal an increasingly desperate interchange between the ship and shore [26]. The Captain rushed to the bridge in an attempt to restore the ship to its original balance, though we are not aware how exactly he tried to do this.

16 April 2014, 08.55 – 09.37 am

After the call that was made at 08.58am, Harbour Affairs at Jeju urged the crew to get passengers ready for evacuation. In the meantime, testimonies say that a loud noise was heard and the Master commanded that everyone stays up. In fact, the passengers continually were taking orders from the bridge not to move. On 09.06 am. the crew was trying to get in contact with the VTS on Jindo Island, which was much closer to the ship's location. On 09.07am the contact has been successful and the crew confirmed the information that the ship was capsizing. On 09.14am. the crew pointed out that the angle the ship was getting, was making the evacuation impossible and four minutes later, on 09.18am, the crew reported that the angle was more than 50 degrees. On 09.23 am Jindo VTS asked from the crew to tell the passengers wear their life jackets and more clothing. When the crew tried to reply the communication was cut off. On 09.25, VTS requested from the Captain to decide to evacuate the vessel, as they did not have the right to take this decision. After Captain's answer, VTS informed that the Coast Guard patrols would have head to the accident's point within ten minutes and the helicopter within one minute. On 09.30am, the Captain gave the command for the evacuation, Coastguard boats and helicopters began arriving and the captain said the ferry was now tilted 60 degrees. On 09.33am VTS, after having secure that all near by vessels are rushing for help, asked the dropping of all life rafts in the sea.

But Captain Lee seek assurance that rescue is at hand. He later said he was concerned that people would be swept away by the sea currents if they entered the swift cold water. The crew was also trapped in the bridge by the angle at which the ship was tilted and by fallen containers, so could not reach the passengers.

16 April 2014, 09.37 am. – 09.41 am.

In the final communication, the crew said an evacuation order has been given and some passengers were escaping on the port side. On 09.38 am the communication between the ship and VTS was cut off. Three minutes later (09.41 am) 160 passengers and crew members began to jump into the sea.

16 April 2014, 09.41 am and after

Over the next two hours, a total of 172 passengers and crew were rescued but many more were trapped inside as the ship was slipping beneath the waves. On 11.18 am, in the sea level only the bulbous was obvious (2 meters height) along with 30 meters of the keel. Nine hours later, on 20.00, only the bulbous was 1 meter above the surface of the sea, while on 01.03 am of 17 April 2014 the ship had already sank. In the time between 08.55 am to 11.18 am of 16 April, testimonies say that passengers who were trapped in the ship were sending messages from their mobile phones, but later all these proved false by an investigation made by the Counterterrorism Service of South Korea. We must note that the water temperature in the region of the accident was around to 12 degrees of Celsius, which means that whoever jumped into the sea was about to get hypothermia within an hour and a half.

6.4. THE RESCUE

The units of the Navy rushed immediately to the point of the accident, after the call they received on 08.58 am. On 09.04 am the government established a committee in order to deal with the accident and on 09.10 am a rescue team was created in the central building of the Coast Guard. On 09.30 am the Ministry of National Defense gave an order for the operation of the Counter-Disaster Headquarters and on 09.40 am the Ministry of Oceans and Fisheries defined the accident as an utmost level alarm event. At the same time, the Ministry of Health sent urgently its vehicles and a specialized team (Disaster-Medical Support team) to provide first aid. In the rescue operation, there were participating also units of the Third Fleet of the Navy, soldiers, aviation units (mostly Chinook and Sikorsky helicopters), 150 men of the Special Forces of the Army, 11 ambulances and 512 divers.

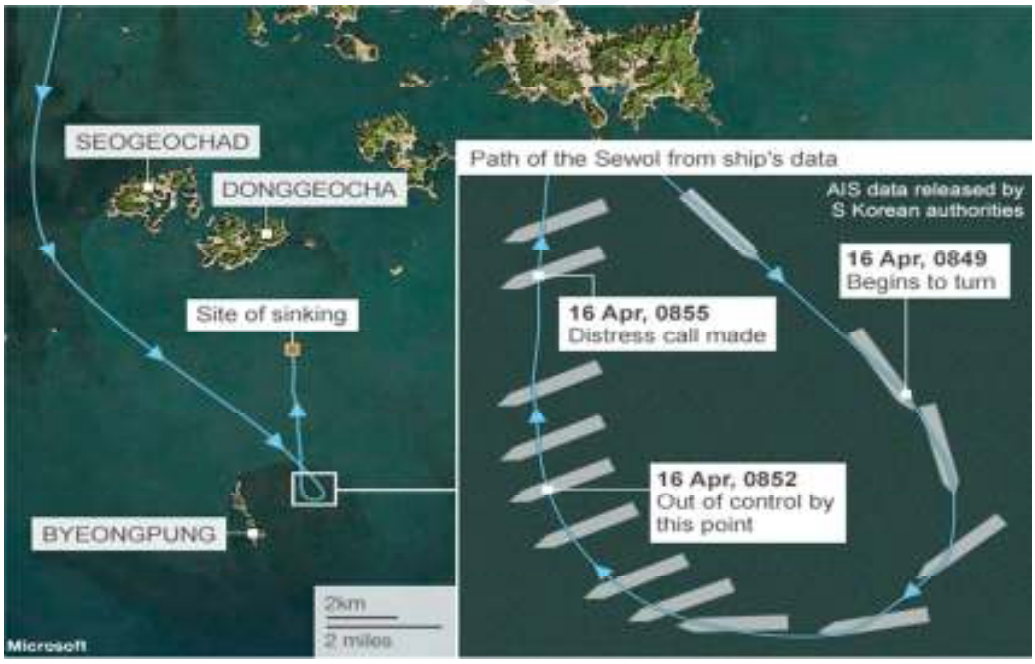
On 19 of April, after the first 3 dead bodies have been pulled from the passengers' cabins, the Coast Guard prepared a draft plan for the salvage of the sunken vessel. In the point of the accident arrived three Samsung and Daewoo giant lifting cranes in order to start the operation after the research for any survivors has come to an end. We must underline that the salvage operation is a very difficult procedure that takes time to be completed.

6.5 CAUSES OF THE SINKING

There are many factors that contributed in the sinking of the vessel and the loss of so many human lives. Below we analyse some of the suspected factors behind the tragedy.

1. The sharp turn

Sewol was following her usual course until the sharp turn. An unexperienced third mate was guiding and steered the ship. The sharp turn to starboard caused cargo to shift. That was the official cause according to the ROK (Republic of Korea) Coast Guard. The shifted cargo exceeded the ability of the ship to self-recover using ballast and trim tanks (Paul Bruno, maritime Expert, 2014). ROK Coast Guard also states in the official explanation that the AIS data confirms a sharp turn to starboard. AIS data is captured by outside receivers and there is no indication that the data from all sources is not identical [29]. This is nearly as good as virtual evidence of the sharp turn.



Map 6.2: Sewol's sharp turn (Source: www.bbc.com)

[29] http://maritime.about.com/od/Innovation/fl/Cause-of-the-Korean-Sewol-Ferry-Capsize-and-Sinking.htm

As we described earlier, the crew member named Helmsman Cho, under the order of the third mate Park Han-Gyeol, made turns to the starboard, with the second one of 10 degrees in one second. This second turn was considered especially sharp, as most large passenger ships would take two minutes to make a 5 degrees turn [24].

A sharp turn can cause the sinking and there are many reasons which can justify that. Of course a sharp turn cannot lead to that result by itself, there is a need of more assisting factors for the sinking to occur. First of all, if the ship has a very small GM (Meta Centric Height) or negative GM, a sinking by a sharp turn can occur [30]. GM is a measure of the ships initial stability [24] and a design characteristic of ships (Image 6.2). The value of GM is determined by a number of factors including a vessel's length-beam ratio, underwater cross-sectional profile, waterplane coefficient, the placement of specific weights, the amount of freeboard and others [31]. Less stable ships have smaller GMs and a longer roll period. A larger GM implies greater initial stability against overturning. Metacentric height also has implication on the natural period of rolling of a hull, with very large metacentric heights being associated with shorter periods of roll which are uncomfortable for passengers [31].

Hence, a ship with a small GM will be tender. An excessively low or negative GM increases the risk of a ship capsizing in rough weather. It also puts the vessel at risk of potential for large angles of heel if the cargo or ballast shifts [24]. A ship with low GM is less safe if damaged and partially flooded because the lower metacentric height leaves less safety margin [30]. For this reason, maritime regulatory agencies such as the International Maritime Organization specify minimum safety margins for seagoing vessels [24].

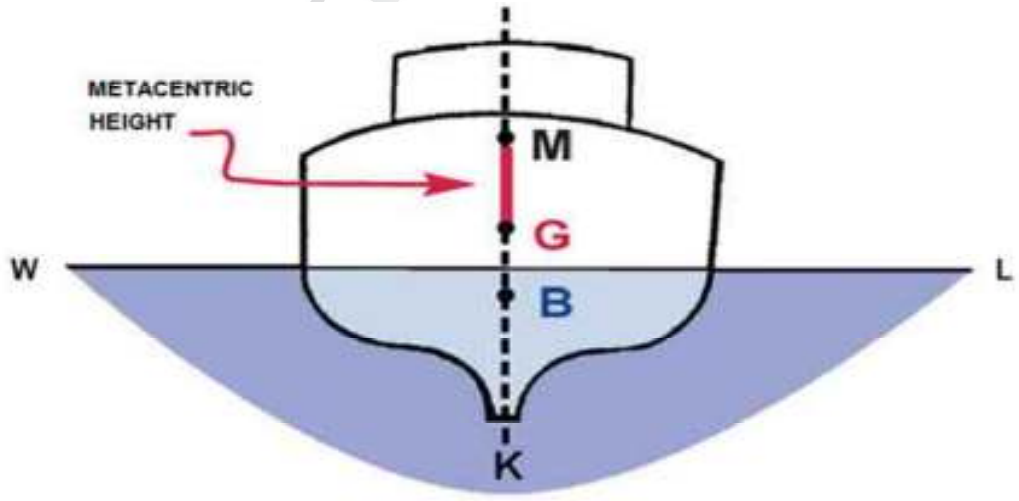


Image 6.2: Metacentric Height – GM of a ship.

[30]http://www.seanews.com.tr/

[31] http://www.gwpda.org/naval/gmdefn.htm

A larger metacentric height on the other hand can cause a vessel to be too "stiff"; excessive stability is uncomfortable for passengers and crew. As greater the metacentric height goes, righting lever increases accordingly (Clark, 2014). It corrects the ship to come upright again. If a ship floods, the loss of stability is caused by the increase in KB (the distance from keel to centre of buoyancy) and the loss of waterplane area which decreases the metacentric height [30]. This additional mass will also reduce freeboard (distance from water to the deck) and the ship's angle of down flooding (minimum angle of heel at which water will be able to flow into the hull) [24]. The range of positive stability will be reduced to the angle of down flooding resulting in a reduced righting lever. When the vessel is inclined, the fluid in the flooded volume will move to the lower side, shifting its centre of gravity toward the list, further extending the heeling force. This is known as the *free surface effect* [31]. The island group on the Port side of the ship may indicate that the ship altered course to Starboard and not to Port.

If MV Sewol was not in a collision with a submerged rock or any other unknown object, then, most probably, the ship had a very narrow metacentre height and large heel periods [30]. As the officer on watch was unexperienced, the use of the helm with a great angle could lead in a big outwards heel. In such a sharp turn, when the wheel is put over, the initial heel is inwards, because the rudder force is acting at a point below the centre of gravity of the ship. As the ship begins to turn, the centripetal force on the hull (which is greater than the rudder force), acting through water pressure at a point below the centre of gravity, overcomes the tendency to heel inwards and causes her to heel outwards [30]. This outward heel is very noticeable when turning at good speed. If the wheel is eased quickly the angle of outward heel will increase, because the counteractive rudder force is removed while the centripetal force remains, until the rate of turning decreases (Ship Manoeuvering, www.scribd.com). Should an alarming heel develop, speed should be reduced instantly.

Answers why was the ship's rudder put at a very large angle which resulted in the sharp turn and heel may vary: there might have been another ship, a sailing or fishing boat. There are testimonies that the third mate Park, who was monitoring the radar, came to believe that another ship was approaching in a collision course. Other reasons can be that the island was too close on the port bow due to a drift (remembering the strong currents in the area, drifting should be expected) and the inexperience of the officer might have played a role here and caused the officer to panic forcing her to put the helm hard to either side. The inexperience of the watch officer could have played a role here because if she was aware of the metacentre height of the ship, she would not have done so.

On the other hand, the officer on duty said to reporters that the vessel did not make a sharp turn, but "the steering turned much more than usual". According to Captain's Istikbal interpretation that means that the officer did not give a rudder command with a big angle. However, due to an error by the helmsman or a technical failure, the rudder went all the way to the side. Well, hard to port or hard to starboard is an

exceptional order which is commonly used in harbour operations but never –except in case of an emergency- on a ship with little metacentric height at full speed ahead.

Witnesses say that there was a very big noise, a loud "bang". If not crashing to a submerged rock, or obstacle, what could be the cause of this, if not the crashing of cargo, either with each other or with ship's side plates? And, in this case, as the cargo of Sewol were nothing else than cars and vehicles in the garage and some containers on the fore deck, shifting-sliding-overturning of the vehicles at ship's garage during the heavy listing could be the case [30]. The result is an immediate and inevitable capsize.

But the speed has also come at a price. A closer examination shows that it is not at all impossible that from the beginning due to the delay in the port of Incheon, maybe the crew wanted to gain some time and was sailing father that it should. The high speed has contributed in the big angle and thus to the later shifting of the cargo. However, there was another version relevant to this scenario, which says that the rudder was stuck. In fact, it was said that the Captain had asked by a paper on April 1st the repair of the rudder. Despite all these, the repairer reported that there was no such a deal with the Shipowning Company. If there was the possibility to support this scenario, then the sharp turn by 45 degrees and the simultaneous angle of the ship to the left can be justified. This angle was probably maintained by the shifting of the cargo in the garage and the bow.

2. Overloaded and unsecured cargo

According to South Korean Investigators, the ship was carrying more than double its limit when it capsized. Before the last voyage, Sewol was loaded with 2,142 tons of cargo, twice the authorized limit of 1,077 tons, and 761 tons of ballast, less than half of the required 1,695 tons [32]. Since Chonghaejin Marine Company started the Incheon to Jeju route in March 2013, 57% of its trips carried excess cargo (139 times out of 241 trips), according to the prosecutors [33]. The company profited from overloading the ferry, earning an extra profit of $2.9 million since March 2013, investigators say. Ironically, more cargo may have helped limit shifting and the ship may have been able to recover. Some reports say the parent company saw a huge loss on the vessel operations since cargo rates are low and the airfare from Incheon to Jeju can be as little as $40USD which is one quarter the price of the ferry. Overloading the ship is one possibility for capsize but because an overloaded ship sinks differently than a partly loaded ship that suffers a catastrophic cargo shift. This has all the signs of a cargo shift but overloading and poor load management can lead to shifting cargo.

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[32]www.wikipedia.com

[33]www.cnn.com

Sewol had 921 passenger and 130 vehicle capacity. The shipowning Company Conghaehjin Marine had reported that the hip departed from the port of Incheon with a total of 657tons of cargo. After the accident though, it was revealed that the ship was carrying a 3,608 tons of cargo, but it had a certificated for a 987 ton of cargo! Thus, it was loaded 3 times more than it was allowed to. Moreover, after the incident that company reported that the vessel was carrying 124 cars, 56 trucks and 422 passengers. Later, it was revealed that the vessel was carrying on board 477 passengers, 180 cars, 57 trucks and 4 heavy type excavators. This means that the stability of the ship at departure was marginal and as a result any sharp turn would have caused a forcible redistribution of the weight and thus overturning. The improperly secured cargo was loaded to twice the legal limit and is estimated to have been worth around □200 billion. Investigators have been probing the possibility that the sharp turn may have shifted the cargo, knocking the vessel off balance. Witnesses have described how several containers fell over and made booming sounds as they tumbled off balance. Loosely tied goods contributed to the Sewol's sinking, because the cargo hadn't been tied properly.

But why did not the crew prevented the overloading, as they were seeing that it is more than the allowed limit of the vessel's capacity ? There is the possibility that the crew had removed a part of the water ballast in order to create space for more cargo. This fact was confirmed by an article in the "Korean Times" (06/05/2014), as the unlucky ship had 580 tons instead of 2.030 tons like it was anticipated to. Moreover, in a publication in "New York Daily News" (04/05/2014), there are articles that reveal what we said before, that the ship was systematically overloaded the last 13 months in a total of 246 trips.

3. Captain's and crew acts

Reports say that the crew and obviously the Captain, underestimated the situation at the very first instant. A good risk evaluation would have resulted in notifying all crew and passengers to gather at muster stations. Ship's emergency alarm should be sounded. However, this was not the case. The passengers were asked to stay in their cabins, assuming this would be safer.

"Please do not move from your location," the ferry's loudspeakers blared at those on board. "Absolutely do not move." This type of warning was heard repeatedly as the Sewol began its descent into the water. Hundreds of passengers, unable to tell what was happening, complied. The instruction to remain in place, instead of getting on lifeboats, has been described as "terribly, tragically wrong" by one CNN analyst. The announcements were made by a communication officer, Kang Hae-seong, who had not consulted the manual before the broadcast. Other crew members corroborated with this order, instructing passengers to stay put. It's unclear why the crew made this determination, which remains one of the most haunting and perplexing questions surrounding the incident. A transcript of communication between Sewol and the local authority shows that the decision was made fairly early. At 9:00 a.m., the Jeju Vessel

Traffic Services Center told an unidentified crew member: "Please put on the life vests and get ready as people may have to abandon ship." The Sewol crew member immediately replied: "It is hard for people to move." During communications with the local traffic services center that lasted until 9:38 a.m., the unidentified crew member repeatedly asserted that passengers could not reach life rafts or rescue boats because "they can't move... the vessel has listed."(From transcript).

At the time of the incident, Captain Lee was at his private cabin and immediately rushed to the steering house. He also instructed the passengers to stay put and not to move. After a while, the Vessel Traffic Service (VTS) ordered the crew to inform the passengers to wear personal flotation devices. The broadcasting equipment however was out of order and VTS told them to personally order the passengers to wear life jackets and more clothing. Meanwhile, the Captain insisted that the passengers remain at their cabins, told VTS that there were too many passengers for the helicopter and he could not make a decision whether to evacuate the ship or not. Moreover, during the capsizing, some members of the crew were drinking beer, according to testimonials. The crew also had seven phone calls with staff from Chonghaejin Marine. As passengers stayed in their cabins as instructed, the Captain and crew members abandoned ship. The Captain, the Chief Engineer and the Chief and Second mates were the first people to be rescued. Capt. Lee Joon-seok of the Sewol has come under heavy criticism for abandoning the ship while hundreds of passengers remained on board. Pictures of the Captain in what looks like his underwear hopping into the arms of the rescuer infuriated the nation. President Park Geun-hye described the crew's actions like murder [33].

Captain Cahit Istikbal in one of his articles states that in his opinion *"the Captain knew the small metacentric height that the ship had. If all passengers rushed up to upper deck, this would have worsened the situation by changing the centre of gravity further up. That's why he did not call all passengers to the upper deck, hoping to balance the ship by then"*. Big risk, at the cost of the life of passengers. Of course this is just an assumption. The Captain in an interview in the Korean Press ("Jeju Today", 2004) had said that he had a seagoing experience of 40 years. He was a Master on board of passenger/vehicle vessels and 20 years on board cargo ships. For MV Sewol, he was not the main Captain. He was working on board Sewol 10 days a month, and that means that from the other had he might knew less than the necessary for the ship. Neither for its stability nor for its general situation, nor for its crew. Hence, he was not capable of giving the right orders.

Many people compare this accident to the Costa Concordia one. There are differences though in the way the Master faced the situation. In some ways, Captain Schettino of Costa Concordia handled the emergency situation much better where many more passengers had been evacuated and with much lesser victims in comparison to the Sewol. He had much more time before the ship capsized [30].

So, it is a matter of fact that the poor management played a significant role in the rescue procedures. The behaviour of the crew is characterized as unacceptable. During the time of the abandonment, the crew, having in mind only the rescue of themselves, used the special corridors in which only they have access. Moreover, the crew members that did not abandon the ship, failed to ensure that all passengers were fully and appropriately equipped with the life jackets. No effort was made in order for the passengers to rush in the assembly stations or in the spaces of the survival crafts, which were existing and functioning normally. Finally, the crew did not gave the passengers the possibility to be rescued opening the slides and the pouring barrels. The crew did not have the appropriate setting up and training in safety issues. Basically, their training was nonexistent. At this point, we must report that the company's budget for the safety training of the crew was 2$ US, which was used to buy a paper certificate. During the last year, according to a logistic control to the company, was found that the total expenses for the training of the crew were 521$ US, in comparison to the competitor company which spent 20 times more money for the same reason. All of these show the attention that the shipowning Company paid in safety and security issues.

4. Delays and miscommunication

It is undisputable that the Captain as well as the crew did not assess seriously the critical situation. While it was obvious that the ship was sinking, the Captain gave the order for the abandonment 35 minutes after her partial overturn. This delay is unreasonable. The Captain himself reported that the low temperature of the water and the strong sea currents were factors that may expose the life of the passengers in danger. However, his decision for all the passengers to stay in their places and not to move, has as a result their sure death. When the ship got steeper slope, it was impossible for them to extricate. The fact that all obeyed the commands of the Captain simply is consistent with their Asiatic culture, discipline and panic avoidance. Unfortunately this time, their culture determined their fate.

The first distress call came not from the ship's crew, but instead from a boy on board who used a cell phone to contact emergency services at 8:52 a.m. His call to emergency services gave rescuers a few extra minutes to get to the stricken Sewol as it is listed dangerously before capsizing [33]. Moreover, the ship sent out a distress signal with a delay. The Ministry of Oceans and Fisheries supposed that there was a temporary black out, maybe for 36 seconds at 08.48 a.m. as the AIS did not recorded any news of the vessel's route. However, the Coast Guard was informed for the first time at 8.58 a.m. by a parent who has received an emergency call from its son. Three minutes later, the ship's crew made a distress to authorities in Jeju -- which was the ship's destination rather than near its accident site. In addition, plenty of time was wasted in the communication with the VTS of the islands Jeju and Jindo. We cannot be sure about who is to blame for this delay. The assistance from the near sailing

vessels was not requested and the bridge did not energize the pumping water pumps in order to hold up the sinking.

The whole miscommunication caused delays. From the interrogations it was proved the crew and the captain contradicted all the time about the exact series of the events.

5. Ship's modifications

The modification under which the ship was exposed from December 2012 to February 2013 significantly contributed to the final outcome. The Sewol had been renovated in 2013 to expand the top floor to make room for more passengers. The 20 year old ship was originally used in Japan, until Chonghaejin Marine Co. purchased the ferry in 2012 and refurbished it [33]. Chonghaejin added extra passenger cabins on the third, fourth and fifth decks, raising passenger capacity and altering the weight and balance of the vessel. During the works, decks no 3,4 and 5 were expanded vertically and astern in order to add 240 cabins and increase the passengers' protocol by 14%. As a result, an extra weight of 239 tons was added to the vessel, while the KG (distance from the keel to the center of gravity) shifted by 51 cm higher astern. This meant that the ship should keep the ballast tank levels higher in order to equalize the increased difference due to the shifted center of gravity to a higher level. In fact, this was reported by the Korean Register of Shipping, but we do not know if the shipowning company did it later. However, the Korean Register who inspected the ship certified it. In addition, there are suspicions that in the shipyard in Mokpo, some loading spaces were constructed illegally in order to increase the carrying capacity of the vessel, which was not foreseen by the original plans of the refurbishing.

Investigators want to know if the renovations may have made the ferry more likely to capsize or raised the ship's center of gravity. The South Korean Ministry of Oceans and Fisheries announced in late April that it would ask lawmakers to consider legislation prohibiting modifications to ships to increase passenger capacity. The government plans to take away the company's licenses for all its routes, including the one on which the Sewol sank, according to an official at the ministry [33]. Below there is a picture showing the capacity of the vessel for decks no 3,4 and 5 after the modification.

Image 6.3: Sewol's capacity. (Source: www.boatdesign.net)

6.6 THE KOREAN REGISTER OF SHIPPING AND THE KOREAN SHIPPING ASSOCIATION

In contrast to other countries, it is said that in South Korean, two entities of the private sector of the maritime industry are responsible for the safety control of the ships that travel and those are:

- The Korean Register of Shipping (KRS): responsible for the necessary assessments concerning the carrying capacity of the ships, and
- The Korean Shipping Association (KSA): the members of which are shipping and management companies.

However, several of the senior executives, members of the KSA's staff, are also part of the Ministry of Oceans and Fisheries, and thus sometimes it is difficult these persons to be controlled by the government. In other words, the Ministry officials often hesitate to ask questions to the senior executives of the Association. These senior executives usually were ex senior public servants or ex supervisors of the latter. Moreover, sometimes there is a conflict of interests in within the KRS, as its special inspectors are working also as independent experts, undertaking contract works outside the KRS. This problem in South Korea is what we mentioned before as "revolving door". So, may the legislation of the country be strict but it is implemented very loosely, as the Professor of Shipping and Oceans of the National University of South Korea, Mr. Yun Jong-hwui had reported. The two main pillars of the maritime system of South Korea, with the one recording the volume of the transferred cargo and the other setting the cargo's limits, it is proved that they are not cooperate effectively with each other. As we see, there is no obligation for exchanging information. However, the legislations obligates the KSA to report to the Coast Guard and the Port Authorities whichever violations. The KSA is denying to give the information of how often that reports are given. It is worth saying that in Europe, North America and Japan, the inspections are performed in majority by departments of the public sector, like the U.S. Coast Guard of the U.K.'s Maritime and Coastal Agency. In fact, in Japan the government makes annual announced inspections to check the ability and the qualifications of the crew and their training sufficiency in safety matters in case they have to face an urgent situation. Similar activity we have also here in Greece by the Control Industry of Merchant Ships.

It cannot be denied that this accident undoubtedly affects the validity and reliability of the Korean Register of Shipping. The KRS is responsible for the supervision of the construction – refurbishment not only of the Korean ships, but also the foreign one that are being built in the Korean shipyards. On April 29, the chief manager of KRS, Chon Young-kee announced his resignation, an act for trying to smooth the situation. However, the criticism for the safety issues and for the practices of KRS and KSA was already diffusible. In fact, during the check that has been made in another

passenger vessel of Japanese shipbuilding (OHOMANA, 1989), after the wreck of the unlucky Sewol, there have been found 40 life rafts non operational, unsufficient rescue systems and a lot of other shortages. Furthermore, the prosecuting authorities issued arrest warrants for three dignitary members of the KRS, blaming them for destroying proving evidence and for being corrupted by the KSA.

Both departments are being carefully checked after the Sewol accident, as from the research has come to light the corruption in the shipbuilding industry of the Asiatic country. It is worth to note at this point that the KSA was partly funded by the government and it was authorized to inspect and certify certain types of ships on behalf of the government. In the KSA are belonging 71 safety inspectors to 13 South Korean ports and the organization operates 11 terminal stations. Moreover, KSA supervise the training courses of the crew and sales insurances to its members. We can verify that, by the organization's budget of 2014, 107 million dollars (75%) have been transferred to the Insurances Department and only 7,2 million dollars have been given to the Safety Department for passenger ships of the internal water lines.

These researches explain the reasons why Koreans are not building passenger ships. According to the leaders of the Korean shipbuilding industry (Daewoo, Samsung, Hyundai), in the country passenger and vehicle ships are not being built as there is no capability for this and their construction is not profitable. The construction is uneconomic as there is the need of full detail in the design and the security levels, as well as in the materials that have to be used. For this reason, Koreans cannot easily satisfy the demands of their clients. This means that all the ships that have been built there in the last 15 years have been order from European companies. We must underline hear that every company that has built ships in the Korean shipyards, has sent her own experienced teams to supervise the construction. By doing so, they secured the last outcome. To sum up, the three biggest Korean companies built the 30% of the commercial ships in the world. Each one costs at around 100 million dollars, while this amount may reach 1 billion dollars for special constructed vessels. So, it is clear why the ship domestic companies do not order newbuilding ships. They are expensive and as a result the companies prefer to buy from Europe and Japan and to reconstruct them, without follow the strict safety rules of Europe and Japan, as they do not have the appropriate expertise.

Returning now to the Sewol accident, we have to mention that the KRS did not check thoroughly if the Shipping Company followed the regulations. After the modification, the KRS limited the carrying capacity of the vessel more than half, while the passengers' protocol had increased. This report was given only to the Shipowning Company. It was not shared neither with the Coast Guard nor with the Korean Association of Shipping, responsible for the arrivals' and departures' control of the passenger vessels. So, even if there were evidence about the usual overload of the ship, those two organizations have no idea about the ship's new carrying limit. We are unaware if the condition of the hull and the operation of watertight fences have been

checked. Probably yes, but under which procedure and who finally got informed about the conditions? We have to suspect the Shipowning company maybe knew but her only matter was to make profit by overloading the vessel. This assumption is made as according to the experts, Sewol after her remake had limits set by the Korean Registry of Shipping about her carrying capacity. As a result, the vessel was no longer profitable for the company. Concluding, according to the practices that are valid until today in South Korea, information concerning the ship's condition is not needed to be shared by the Register in charge to the Coast Guard and the Shipping Association. As result, the information is being useless and at the same time dangerous for the passengers' safety.
(Source of data: "Efoplistis", "MER", "Shipping News")

6.7.THE SHIPOWNING COMPANY

As shareholders of the company Chonghaejin Marine are the sons of Yoo Buyng-eun, who is known in South Korea as the "businessman without face". None of them has been showed anywhere during the rescue operations and the investigations, but only the CEO of the company Kim Han-sik when he reported in the public that the vessel did not fulfill the necessary requirements of safety and security. Until May 2014, the only reaction from the company has been made through the legal advisor Son Byoung-gi who stated that the company will announce her position right after the completion of the investigations [27]. In fact, he added at his speech that if any legal liability occurs for the company, the owners are willing to offer part of their fortune to indemnify the families of the dead passengers. Yoo Buyng-eun has been the Managing Director of the bankrupted Semo Ferry Cruise Company, which was managing ships in the Han river until 1997. Moreover, he was a pastor of the evangelical church and member of a somehow religious organization, for which he was supposed to be guilty the the mass suicide of 33 people on 29th of August 1987. This last case is still a mystery as it has not been clarified if that was suicide or murder. On 1992, he was convicted to a 4 year imprisonment, as there were never more incriminating evidence against him. On 2099, Chonghaejin Marine reported earnings of 1,9 million dollars, while on 2013 745.000 dollars, that means a decrease of 60% [28].

Moreover, it was discovered that in 2007, Yoo Buyng-eun received loans of 21,6 million dollars from the National Federation of Agricultural Cooperatives (12,4 million dollars) and from the Industrial Bank of South Korea (9,2 million dollars), without first having the necessary checks carried out [28]. These developments have cause the reaction of the authorities of the country, which have moved in a further investigation of the case and in controls to shipowners and managers with respect to all the illegalities to which the company seemed to be involved. The authorities believe that the ex president of Semo Ferry Cruise Company had used the above loans in order to regain the majority of the stocks of the mother company Semo Co [24]. For

this reason, the economic investigators began immediately a special research inside the company and to all other companies connected with her. Furthermore, there have been researches concerning the financial situation and the loaning problems of the mother company I-Onie-I Holdings, which is connected to the Semo Group. The research extended to all the financial transactions of the family in and out of the country. The court Authotities of Incheon discovered more evidence about a series of suspicious transactions of the Yoo family, which seems to have get 48,5 million dollars from companies whose brand names have been published through the family's Group. The member of the family have the right of fortify the brand names of more than 1,600 business in South Korea. For example, the managing Chonghaejin was paying to the family 1 million dollars for each trip of the unlucky Sewol. Generally, the mother company I-One-I Holdings is suspicious for plenty offences, including tax evasion and logistic fraud. Also, the mother company is in the center of a multi connection of shareholdings, which gives to the Yoo family the control of a large number of businesses.

Just for the information, it is worth to mention that according to the Korean Service of Financial Inspectors, the shipowning company of Sewol belongs to Chonhaejin, which specializes in the construction of container ships, tankers, bulk carriers and LNGs. The latter belongs to the group of the mother company I-One-I Holdings, with the main shareholders Yoo Dae-kyun and Yoo Hyuk-ki, both sons of Yoo Byung-eun. The two of them have the 19,4% of the stocks, while Kim Hye-kyung has the 6,29%. In other words, the 25,73% of the company is under the control of the family [27].

6.8. ACCOUNT OF THE TRAGEDY

The tragedy of the vessel Sewol is the worst in the history of South Korea during the last 2 decades. In total 304 dead and few persons missing, 2 divers dead, 1 navy sailor dead and 172 survivors, these are so far the records. The last tragedy was in 1993 when the passenger vessel SEOHAE was sank under difficult circumstances near to the island Wido. The vessel was overloaded and was carrying 362 passengers (141 more than it was allowed to) and 292 of them were drowned. Some older wrecks are the one of CHANGGYEONG in 1953, with 229 dead people, and the sinking of NAMYOUNG in 1970 with 326 dead people.

6.9 WHAT HAPPENED NEXT

After 7 months of systematic researches the ones to blame for this unprecedented tragedy which had shaken the world, have been convicted. The penalties that the Korean Authorities have imposed were exemplary, the activities of the Shipowning company have been stopped and the political leadership of the country proceeded to sweeping changes in a political and business level. Let's take a look now in the time sequence of the events after the wreck.

The Ship Master and the Crew

On 19th of April 2014, the Master of MV Sewol Lee Joon-seok was arrested as a suspect for improper performance of his duties, violation of the maritime legislation and other deficiencies. He had abandoned the vessel, leaving behind all the trapped passengers fighting for their rescue, while they have been given the order not to move from their position. We must note that the legislation of South Korea specifically requires the stay of the captain in the ship for the management and the coordination of such a difficult situation.

The same day, two more members of the crew were arrested, the Chief Mate and a sailor. The charges against them were about negligence and manslaughter. In April 26, the authorities proceeded with 12 more arrestments of mates. In May 15 the prosecutors indicted charges for murder with intent to the captain, to the mate Kang Won-sik (who was responsible for the for the management of the ballast of the unlucky ship), the mate Kim Young-ho and the Chief Engineer Park Gi-ho. According to the Korean legislation the above charges incur death penalty. The rest members of the crew faced smaller charges, mainly for abandonment of the vessel and for offences related to the safety of the ship. We must underline that, as the survivors have reported, only three members of the crew really helped in the rescue efforts. Those were Park Ji-young, Jeong Hyun-seon and Kim Ki-woong, who finally followed the vessel in its watery grave.

The Shipowing Company

In May 8 the CEO of Chonghaejin Marine, Kim Han-sik, was arrested facing plenty of charges, including negligently murder. Meanwhile, four more company members were detained , and the Ministry of Oceans and Fisheries suspended indefinitely the operating authorization of the Management Company for the water line Incheon-Jeju. For the shipowners the developments were equally rapid. The president of Chonghaejin Marine, Yoo Byung-eun, disregarded the subpoenas of the prosecutor of Incheon and tried to escape. In May 22, the court of Incheon issued an arrest warrant

for the latter, while the authorities offered 48,8 thousand dollars to any tipsters. Three days later the reward was multiplied by ten, reaching to 488 thousand dollars. In July 21, the dead body of Yoo Byung-eun was found in a field. According to the authorities, the president of the Company died under suspicious and obscure circumstances.

The Korean Regulatory Framework for Shipping

The unspeakable tragedy of the MV Sewol produced a series of questions about the regulatory framework which controls the operation of commercial and passenger shipping in South Korea. The relevant regulatory body is the Korean Shipping Association (KSA). However, the special inspectors of KSA are working also for the Korean Register of Shipping (KRS) and as independent experts. As a result, a very common phenomenon is a conflict of interests known as "revolving door". So, the South Korean legislation may be strict but it is implemented very softly, said the professor of the University of Seoul, Yun Jong-hwui. The researches proved that the overloaded vessel Sewol was poorly retrofitted in order to increase the number of passengers that is capable to carry. As a result, the vessel was unstable and overly heavy. A great responsibility for this lies on the Korean Registry of Shipping as well as on the Korean Association of Shipping. Under these revelations, the president and CEO of the KRS resigned.

The political Impact

The issue escalated and got away from examining the acts and omissions of the captain and the crew. The criticism to the competent bodies were fierce. The censures were about the lack of regulatory framework, fact that contributed in the infraction of the security and safety rules and hence in the sinking of the vessel. Furthermore, the censures concerned the unacceptable, unsynchronized and slow operations during the rescue. After all these, the popularity percentages of the President of the Country Park Geun-hye decreased from 71% to 40% within a few weeks. As a result, the President decided to reconstitute the foundations of the standards of the national security. One of the most characteristic initiatives that she took was the plan about the dissolution of the Coastguard. Some of Coastguard's responsibilities will be transmitted to the Police and others (rescue operations, safety at the sea) to the fledgling Ministry of National Security.

The Penalties

In June 3, the Court Authorities of Gwangju issued an arrest warrant for the Chief Safety Officer of the Korean Shipping Association on Incheon and for the ship inspector of the Korean Registry of Shipping in Mokpo. In the trial, the defendants were 15 in total. The prosecutors suggested a death penalty for the captain. As they argued in their speech , Lee Joon-seok had failed in the execution of his duties, caused the sinking of the vessel by his acts, and for those reasons he was the major responsible for the marine accident. In November 11, the court found him guilty for neglect and abandonment of hundreds trapped passengers in a sinking vessel and sentenced him to 36 years imprisonment. The three judges considered that he was not the only one to blame for the tragedy and hence they accepted the fact that he had no intention for murder.

From his side, the 69 year-old Captain argued that the shock of the incident paralyzed his ability to take critical decisions and for this reason he did not manage to take that appropriate measures for the safety of the passengers and the discharge of the ship. He underlined that in any case he did not think to abandon the passengers in order to save himself. Moreover, he emphasized in the fact that the sailor Cho Jun-ki was working on board just for six months and as a result the latter did not have the necessary capability and experience for that specific working post. When the prosecutors asked the Master if he had the obligation to take the rudder in his hands while the ship was sailing towards the dangerous pass, well known for its strong underwater currents, he answered positively. In addition, the Captain denied any charges that some crew members tried to complain that during the time of the accident he was playing games in his mobile phone. In contrary, the Captain maintained that he was in his cabin in order to smoke and change clothes and that he has no idea how to use smart phones. In his final testimony, Lee insisted that the real criminals are the shipowners, as the decision for the systematic overload of the unlucky vessel was theirs.

The Chief Engineer Park was found guilty for murder and was sentenced in a 30 year imprisonment, while the rest members of the crew were sentenced in imprisonment penalties from 5 to 20 years. Furthermore, in November 3, the court of Incheon sentenced to two sons of the deceased shipwoner Yoo Buyng-eun in 2 and 3 years of imprisonment relatively. The charger against the two sons concerned fraud and dishonesty that decisively contributed in the sinking of the vessel. In November 20, 8 of the 15 crew members (not the captain) appealed against the decision of the court. Like the defense counsels supported, the crew members panicked as they were not enough trained and skilled for a ship discharge operation.

To the 71 year old Kim Han-sik, senior of the management company, was imposed a ten year imprisonment and fine of 1.900 dollars for the charge of manslaughter. According to the file, Kim had proceeded to the alternation of SEWOL and systematically overloaded the vessel, trying to limit the economic damages of the company despite the fact that he knew that the stability of the ship was marginal.

Moreover, the court supported that Kim caused a serious economic damage to the company though fraud but also by professional incompetence. He was secretly transferring funds from the company's treasury to the family of the deceased shipowner Yoo Buyng-eun, while later he tried to fix the damage by adding more cabins to the upper deck, in order to host a bigger number of passengers, and by entering into illegal agreements with logistic companies and port inspectors. As a result, he was overloading the vessel knowingly and systematically. Kim Han-sik in his apology statement addressed to the families of the victims saying that he was just an employee and that the decisions were taked by Yoo Buyng-eun, de facto owner of Chonghaejin Marine.

Moreover, the court condemned 3 to 6 year imprisonment penalties with suspension to the rest executives of the company, judging them guilty as they knew that the ship was dangerous and despite that they allowed it to travel. We should remind at this point that there was in total 476 passengers on board and only 172 were rescued. The rest 304 are confirmed dead of missing. 250 of them were students of Danwon lyceum. On the occasion of the wreck and as part of the reorganization of the competent departments, some time ago was established in South Korea the Super-Ministry of National Security and Protection with more than 10 thousand employees.

But, despite the fact that the long lasting judicial investigations were completed, the relatives of the victims think that they have not yet received satisfactory answers for the real reasons that led to the loss of their loved ones. They reacted angrily when they learned about the penalties and they thought that they were too indulgent. For this reason, 8 months after the tragic incident, the parliament of the country decided to conduct a new, full and independent research for the reasons of the wreck which exhibited and traduced internationally a well known country as one of the most powerful shipbuilding industries of the planet earth. The impact of the tragic shipwreck cannot yet abated.

(Source of data: "Efoplistis", "MER", "Shipping News", www.businessinsider.com, www.cnn.com, www.bbc.com)

CHAPTER 7 - CASE STUDY 2

7.1 MV COSTA CONCORDIA

Image 7.1: MV Costa Concordia (Source: www.marinetraffic.com)

Type of the vessel: Passenger Cruise ship

Type of the event: Grounding

Date: 13th of January 2012

Time: Around 10.00 pm Italy Local Time.

Location: Off Isola del Giglio, Tuscany
Italy, Mediterranean Sea
Coordinates 42°21'54"N 10°55'17"E

Deaths

32 Passengers and Crew

1 Salvage Member dead

On board in total 4,252 (3,229 passengers and 1,023 crew)

(Source of data: www.cruiseshipsinking.com)

7.2 THE VESSEL COSTA CONCORDIA

Costa Concordia was a Concordia-class cruise ship that means that the vessel was belonging in a class of ships that they were operated by Costa Cruises and Carnival Cruise Lines, affiliate companies of Carnival Corporation and plc. The ship was ordered in 2004 from Fincatieri, an Italian shipbuilding company based in Trieste. The vessel was built in the Sestri Ponente yard in Genoa [34]. The subsidiary company Costa Crociere operated the vessel from 2005 until 13 January 2012, when the vessel was wrecked off the coast of the Island Giglio in Italy. The ship was delivered on 30 June 2006 bringing the number of ships in the Coast Fleet up to 11 and she cost 570$ million to be built.

The ship had a 114,147 grt and a 3,780 passengers and 1,100 crew carrying capacity. Costa Concordia was 290,2 m long overall with 35,5m beam and 8,2m draught. She has 13 decks and could reach a service speed of 19.6 knots (with 23 knots maximum speed). When the accident occurred there were on board 3,229 passengers and 1,023 crew. In regards to the interior of the vessel, she had in total 1,500 cabins. 55 of them and 12 suites had an immediate contact with the Samsara Spa the largest wellness center ever built in a cruise ship. Moreover, the ship had four swimming pools, 2 of them under a retractable glass roof (one astern and the other amidships on the same deck. Finally, she carried five Jacuzzis, five spas and a possible movie theater in the pool deck, five restaurants and thirteen bars .

By the time of the construction, Costa Concordia was the largest cruise ship flying the Italian flag and the biggest European Passenger Vessel in terms of capacity. As the president of Costa Crociere, Gianni Onorato had stated the ship was “a veritable showcase of innovation and state-of-the-art technology” [34].

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[34]www.fincatier.it

On 22nd of November 2008, the luxury cruise liner sustained damage to its bow when a force 7 storm hit Palermo, though no one was hurt. In regards to the stability and buoyance the vessel was considered that she was sufficing all the regulations and the criteria of SOLAS 1990 as a ship of two compartments.

In the table below, we provide full details for the M/V Costa Concordia :

IMO: 9320544	**Gross Tonnage: 114.147**
Call Sign: ITMCC	**Dead Weight:** 8.900 t.
Flag: Italy (IT)	**Length x Breadth :** 290,2m. x 62m.
AIS Type: Passenger	**Year Built:** 2006

Table 7.1: MV Costa Concordia (Source: www.marinetraffic.com)

7.3 THE ACCIDENT

TIMELINE OF THE EVENTS

Below we are presenting a timeline of the series of the events the night of the accident, as they were stated by the media and the later official reports.

13 January 2012, Evening

In the late evening of Friday 13th January 2012 the cruise liner vessel MV Costa Concordia departed port Civitavecchia and headed towards the island of Giglio, in full compliance with all the SOLAS applicable regulations and matching all the related requirements. The island was about 45 nautical miles away from the departure port. We should mention here that according to Captain's Francesco Schettino orders, the cruise ship steered close to the island of Giglio as a "salute" [26].

At 09.37pm the vessel is in a 2 nautical miles distance from the Island of Giglio and sailing in a course showing that she was intended to pass by the port of the Island, like on 14th of August 2011. However, the route was showing that the ship was heading into the southernmost bay Cannele.

At 09.39 Costa Concordia turned to the north in order to sail near the coast. The Captain having noticed that the vessel is not approaching the right bay, turned the rudder to the right in order to avoid hitting the rocks.

At 09.42 pm the ship struck rock formations very close to the port of Giglio. The vessel sustained considerable damage by the contact and as a result a rift of 50m long was created. That rift was starting from the bottom of the ship up to the waterline on its port side (left) (European Commision Report, 2012). It is stated that the rift was at the engine room of the vessel and caused damage to 3-4 compartments of the vessel. The water started flooding the engine room and this caused a temporary total black out on the ship and loss of the engine power, till the start of the emergency generators. The Captain turns the ship to the right to counterbalance the lifting from the side of the rift. The service speed of Costa Concordia at the time of the hit was 16 knots.

The Captain and the crew got in contact with the Italian Authorities and informed them only about the blackout. The Coastguard quickly located the ship via the VTS (Vessel Traffic Station) of Livorno which could display the Automatic Identification Signal (AIS) being broadcast by the Costa. Both the passengers and the Italian Authorities were informed incompletely neither about the rift nor about the flooding.

At 09.53pm the MV Costa Concordia is 0,5 nautical miles of the port of Giglio. The speed had fallen to 3 knots and was decreasing more as the time was passing. The Captain threw the right anchor in an attempt to keep the vessel near to the coast in order for the evacuation to be easier.

13 January 2012, 10.00pm and after

The ship has already taken a significant gradient of 7-10 degrees to the left. Despite that fact, as we said, the Captain, probably sensing the gravity of the situation, gave command for a 180 degree turn trying to reach to the shallow waters of the island Giglio. According to the reports, the ship after that turn lost forward motion and she was pushed towards the coast, probably by the wind that was blowing then. As it drifted, the ship then began to list in the opposite direction [26].

At 10.10pm the MV Costa Concordia run aground and "stayed" in the shallow waters in an around 50 m distance from the coast in the north side of the port bay of Giglio.

It was only around 10.22 pm when the Captain contacted to MRSC and gave the information that the ship was listing and was taking in water. Any merchant vessels that were close to the Island of Giglio have been commanded to approach the cruise ship and get ready to provide assistance. In total 22 surface vessels, 8 helicopters, 10 merchant vessels and 4 tugs were altered.

Having taken that course, the cruise ship made once again contact with the bottom on the northern side of Giglio port, she came to a stop and she was tilted 80 degrees to the right side. This second contact happened at about 10.45 pm. Until that time, the passengers have already been given lifejackets and the crew had made contact with the Coastguard telling them that they need help from tug boats due to a "failure" [26]. The captain finally gave the order to abandon the ship at 10.54pm, that means 70 minutes after the first contact and after the ship had arrived to the shallow waters of the Giglio Island. Hence, they have lost valuable time for the rescue of the thousands of passengers, who were on board the cruise vessel. Moreover the tilting angle of the vessel made the launch of the lifeboats from the left side of her, very difficult. Also, in this position the starboard side of the ship was completely submerged with the upper deck facing the coast, in a distance of about 50m from the rock on shore (Official Report MIT, 2014).

13 January 2012, 11.40pm and after

With the second master having left the bridge and only few of the passengers to have been rescued by lifeboats, the Captain abandoned the ship at 11.40. Still hundreds of people, among them women and children, were on board the unlucky ship.

After the completion process the vessel was lining in 190-010 degrees and the tilting angle was changed.

Below we are presenting a picture with the previous and the "accidental" route of MV Costa Concordia, as it has been published by the Lloyd's List.

Map 7.1: Routes of MV Costa Concordia (Source: www.bbc.com)

7.4 THE RESCUE

In total, 4,229 people were on board MV Costa Concordia during that last cruise. Among that people there were also 1,000 crew members. As we mentioned above the command to abandon ship was given only a few minutes before 11.00pm. This is when the first life boats were launched at the sea with a number of passengers. The ship was close enough to the mainland and to the port, making the reach of the rescuers quite easy. The evacuation process had started and in the first 30 minutes 3,000 people were successfully evacuated from the ship and delivered to the port of Giglio. Most of the transfers have been made by the life boats of the vessel. There were also passengers who swam the distance to the shore. Whoever was injured was transferred directly to the hospital by helicopters.

The operation of the rescue came to an end the next day in the morning (14th of January 2012) saving 4,194 persons. Three more persons were rescued on January 15th. By Sunday 29th of January 2012, 17 persons were confirmed dead and 15 were still missing. On 22th of March, the last victim was found and the dead were finally 32 (26 passengers and 4 crew members), with 2 of the bodies not to have been found.

After the rescue the days of the incident, the Authorities of Giglio gave to the evacuees all the medical care and temporary accommodation they needed to cover from the accident. The local ferries started to transfer the rescued passengers to the mainland to Santo Stefano port where more robust infrastructure could deal with the very large number of survivors and their special needs (European Comission Report, 2012).

We should state here that the time range of the evacuation of a damaged vessel is very critical. The planned renovation times for the information of an urgent situation by the master and the Abandon Alarm, the realization by the passengers that they have to abandon the vessel, their gathering to the assembly stations, their embark to the life boats and the launch of the life boats is about 60 minutes, whatever the size of the ship and the number of the passengers is. Of course, this time range is beyond the actual needs of mega cruise ships of an orderly evacuation, which will require a few hours. In case of accidents, the evacuation takes place inside the time limits before the sinking of the vessel by every means. Of course the number of the human lives that might be lost are a consequence of a lot of factors, like in the MV Sewol case, where the number of the victims was quite large. The reliability of the saving appliances, the capability and the training of the crew, the coordination of the rescue teams and the weather conditions are very important factors for the evacuation operations. In the Costa Concordia case most of that factors worked well to minimize the loss of human lives (0,8% of the passengers on board).

Anyway, the time before the sinking of a vessel (time to capsize, TTC) after an accident is the basic factor which defines the successful evacuation of the vessel and

the number of lost human lives. The TTC time is an object of scientific research for different accident scenarios. Generally, the IMO regulations should be improved for safety and evacuation issues of passenger vessels. Finally, there should be upper limits for the jeopardizing of vessels, in order for their risk level to be of social acceptance.

7.5 CAUSES OF THE ACCIDENT

1.The rift and the size of the vessel

The MV Costa Concordia sidetracked significantly from her initial course and hit in rocks for which by then it was not clear if they were rightly mapped and stored in the ECDIS system of the ship. The change of the route was made by the initiative of the Captain, who's family lives in the Island of Giglio. As we can see in the map we presented in the "Timeline of events" section, the same sidetracking had been made again on 14th of August 2011 for the honor of a local festival on the island. The shipowning company was aware that 1st time of the change.

Taking into consideration the intensity of the hit (also relevant to the speed and the volume of the vessel) and the kind of it (prolonged contact with the rocks) the length of the rift was quite expected. Of course, we have to mention that such rifts are not caused easily and often. In the case of Costa Concordia the rift reached the level of the waterline! This can be explained by the morphology of the rock, which was not a reef but it was extended above the surface of the sea. Moreover, the stabilizer remained attached from the contact of the vessel of the rocks. This showed that an attempt to avoid the hit was made, a case that later was confirmed by the testimonies of the Captain to the Authorities.

Taking into consideration the length of the rift, the sinking of the cruise ship was more than certain. In fact, the sinking might have been accelerated because of the open watertight doors in the engine room or the open semi-watertight doors in higher places of the ship. The fact that the vessel kept sailing in the surface for at least 70-90 minutes before reaching the shallow waters, is an indication of good stability and buoyancy, beyond the low limits of the regulations.

Given the nature of the trips that the cruise ships perform, the possibility of grounding is not often, but it is possible. According to a research of GOALDS (Goal-based damage stability 9of passenger ships) [35] the possibility of cruise ship groundings is 0,01, while the possibility for the vessel to ran aground and continue her course is 0,003. In comparison to other maritime accidents and other transportation sectors, these possibilities are quite high and need the attention of all the pertinent national and international authorities (IMO). Apart from the human error, which is our occasion also plays a significant role, the passive security of the ship to eliminate and face the consequences of such accidents is critical.

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[35] http://www.goalds.org

The specificity of that accident was the extend and the morphology of the fracture, which was not covered by any stability regulations after grounding and collision damages. The size of the cruise ship was also of a significant importance. She belonged to the category of Mega Cruise Ships but she satisfied stability regulations of the 80s (SOLAS 90), when there were not cruise ships of that size. By now largest cruise ships have been built, for example the Oases Of The Seas.

2.The acts of the Human Element

On the whole, human factors characterized this casualty (Official Report MIT, 2014). To illustrate the human factor perspective the crew on the Costa Concordia noticed that the risks increased by how they were sailing (Hollnagel et al, 2012). He human element is accused for the result of the vessel's trip by two aspects: the unconventional action which caused the contact with the rocks and for the general emergency management (MIT Official Report, 2014).

First of all, the navigation is the most crucial action and the one which originated the vessel's casualty (by hitting in the rocks and causing the rift). The person to blame for this is the Captain himself. He ordered the ship to sail into dangerous and restricted water close to the shore, under an already high speed of 16 knots. The Master tried the last minute to change the wrong route which represents an aggravating in his nautical behavior (MIT Official Report, 2012). Moreover, he used inadequate cartography and inappropriate application of navigation systems as we mentioned above. However, according to testimonies and the black box recordings, the crew on the bridge, although they have criticized their Master's decisions, they did not warn him about the dangerousness of his actions. From the investigation it became clear the arbitrary attitude of the Captain to review the original navigation plan. A miscommunication, lack of organization and not clear division of duties in the bridge have been detected as serious contributed factors for the Coast Concordia accident.

Second, the on board organization and the emergency management were poor to handle that urgent situation. The General Emergency Alarm was not activated immediately after the impact and that led to a delay in the organization of the flooding-abandon ship process (MIT Official Report, 2014). Moreover, the miscommunication among the crew members but also between the crew members and the passengers has as a result many of the passengers to take initiatives by themselves in accordance to the abandonment of the ship (some of the survivors jumped into the water and swam to the shore). Such events reveal main flaws in regards to the safe manning of the ship and confirm what we said earlier in this paper. The recruitment is a very important procedure which must be done carefully. The crew must be able to communicate with each other, to pass the information, have well assigned duties, be well trained, know how to manage urgent situations under the pressure of time and realize that they are in some point responsible for the human lives on board the vessel.

From the above, we conclude to the fact that distractions, errors and violations can be established as the elements which characterized the human factors as root causes in the Costa Concordia accident (MIT Official Report, 2014). Distractions and errors have been made by the Captain before hitting on the rocks, by the crew members on the Bridge and by the crew and their weakness to manage the situation after the contact.

Last but not least, the contribution of the SAR Authority was also very important. The SAR Authority had not been informed in a suitable way due to the delay and the lack of information by the ship. However, their intervention to the rescue operations was successful. Not only they rescued the one third of the total passengers on board Costa Concordia, but they also helped and supported the rescue operations conducted by the ship.

7.6.WHAT HAPPENNED NEXT

After every ship accident, there are consequences and the ones to blame have to be convicted. Below we will describe briefly the events that followed the tragic accident.

7.6.1. ENVIRONMENTAL PRECAUTIONS

There were some environmental recovery issues which followed the Costa Concordia disaster. A few days after the wreck of the unlucky vessel, the Italian authorities heralded the region in a state of natural destruction. There was a major environmental challenge which needed to be taken into consideration (European Commission Report, 2012).

That operation was the defueling of the vessel. A whole operation was conducted for the removal of the fuel from the ship. The MV Costa Concordia was containing 2,040 m^2 of IF 380, 203 m^2 of diesel oil and an amount of lubricants. Before the operation of the fuel removal had started, the whole region around the ship was secured and the navigation of private boats was forbidden. The defueling operation was carried out by experts from the Neri/Smit Salvage Team. The shipowning company Costa Crociere had hire that team to take over the operation, and the works started on 12th of February 2012, one month after the tragic accident.

The defueling operation needed 6-8 weeks to complete. During all this time, the danger of an oil spill was a major environmental risk. A crucial parameter regarding this danger was the stability of the wrecked ship. A possible loss of the stability could have result in a total loss of the amount of the fuel into the environment. The weather conditions were also of a great importance regarding this issue. As the defueling operation was supposed to last enough time, any unexpected wind or current could have caused an undesirable result. At the end, the operation ended successfully and the fuel was pumped out of 17 tanks on 23rd of March 2012.

The shipowning Company invested million dollars to this operation in order to guarantee environmental monitoring and protection and to remove the fuel as quickly and as cleanly as possible [36]. A reason was also the fact that the island of Giglio is considered an environmentally sensitive area, as it is assigned as a national park (European Commission Report, 2012).

[36] www.travelpress.com

7.6.2. THE SALVAGE OPERATION

When the defueling operation ended, it was the time for the removal of the wreck to begin. Of course, with a 290m long and 114,000grt cruise ship to lever upright and refloat, whoever was going to take the job would have to consider how to carry out this huge operation without causing any damage to the ecosystem of the island of Giglio. In April 2012, it was announced that a consortium of US-based Titan Salvage and Italian marine contractor Microperi won the 500€ contract. The work was planned to begin on May 2012 following approval from the Italian Authorities.

A team of Titan and Microperi experts developed a method for the initial stages of the project based on the parbuckling process, where a ship is rolled upright. For the rifting and the refloating of the vessel, a preparatory work was needed. Prior to the prabuckling, the team anchored and established the wreck to prevent it from slipping or sinking along the steep seabed, and increase the weather window it was possible to work in. The stabilization involved four submarine anchor blocks fixed to the sea bottom between the center of the wreck and the coast. This part of the project was completed be November 2012. They also used a holdback system for balancing purposes during the rotation and parbuckling of the wreck.

The second stage of the preparation involved installing a false bottom for the wreck to rest on after rotation. Grout bags filled with cement were positioned by divers in the empty space between two spurs of rock, one in the stern and the other in the bow, to create a stable base for the hull. Then three large and three small platforms were fixed in place with the piles being inserted 2m into the granite seabed. Six undersea platforms for the ship to rest on after rotation to a vertical position were also installed. Fifteen refloating sponsons were fitted to the port side of the ship and caisson were also welded on.

The parbuckling process comprised the strandjacks tightening several cables, attached to the top of the caissons and platforms, being pulled seawards, while the cable attached to the starboard turrets were used for balancing. The parbuckling was completed over twenty hours on 16-17 September 2013. The ship was then turned to a full upright position.

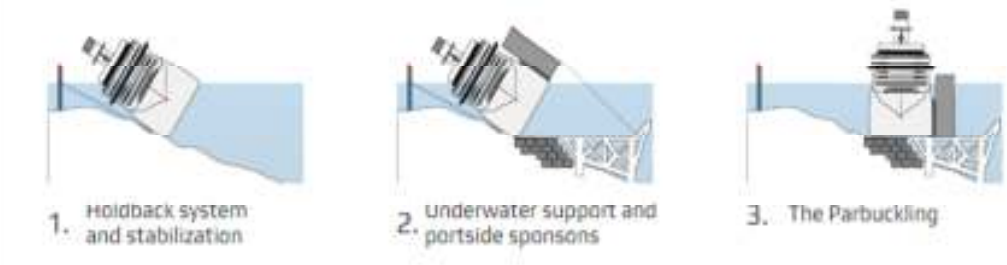

Image 7.2: Parbuckling process (Source:http://www.theparbucklingproject.com)

Following the parbuckling, e ship had now to be refloated. Nineteen sponsons have been attached to the starboard side of the wreck until June 2014. The damaged areas on the starboard side where the structure was crushed under its own weight left indentations of up to 8m and have been covered with large patches of false side shell. This allowed the sponsons to rest on a flush surface. Onboard the ship the team fabricated the pipelines required for transferring all the compressed air to the sponsors from the compressors after they have been installed. A pneumatic system was used to empty the water gradually from the caissons on both sides of the wreck, enabling sufficient power to push it upwards. In total, there was remaining a section of 18m to be submerged.

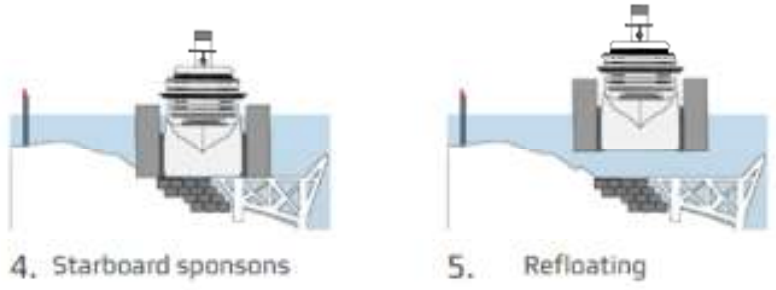

Image 7.3: Refloating process (Source:http://www.theparbucklingproject.com)

On 14th of July 2014, the salvage operators began to refloating the vessel off its submerged platform and towed it north from the Italian island of Giglio. In a few days this operation had been completed and on the 23rd of July 2014 the Coast Concordia began to being towed away to Genoa, in Italy. Of course, with 60,000tons of salvage gear attached to her 114,000grt, the travelling speed of the vessel was about 2knots. It took 5 days (27th of July 2014) to arrive in Genoa port and moor. The whole operation cost about 2billion dollars, more than the 612 million dollars than it cost to be built in 2004.

7.6.3. PENALTIES

The trial for the wreck that cost the life of 32 people on 13th of January 2012, began after the end of the Captain's Francesco Schettino testimonies. Two Chief Officers were found guilty for the wreck. The sailor steersman, the Chief Chamberlain and the Head of the Crisis team were found guilty too. The maximum penalty that was imposed by the court was for 2 years and 10 months imprisonment for multiple manslaughter and for causing navy mishap.

The only one for whom the compromise request was not accepted was the Captain, who had to apologize for manslaughter and for abandoning the ship. Another trial began on 18th July 2013, where the advocates of the Captain proposed a compromise request with partial assumption of responsibilities and convict for 3,5 years of imprisonment. In the trials that are ongoing until nowadays, the Captain is still denying wrongdoing. If he ends up convicted, he is going to face 23 years of imprisonment.

CHAPTER 8 – CONLCUSIONS

8.1. CONCLUSIONS

As we have seen, maritime accidents constitute a big chapter of the maritime industry and are of great concern. All the safety rules and regulations have been invented in order to prevent the marine accidents from happening or at least to prevent an unpleasant result. Many times, the series of events that led to a marine casualty is not reversible. There are cases where external factors have contributed for a marine casualty to occur. Of course, in the majority of the cases, if something had been done differently maybe nothing would have happened.

We can easily conclude to the fact that the human factor is the number one cause for marine incidents, serious and very serious accidents. From the time that a vessel is being built till it is launched at the sea, and during all of its sea life, everything depends on how people operate the processes in every stage of the vessel's life. Even a machinery failure may have been caused by a human mistake in the manufacture or by the operation. So, both people on board ships and people who operate from the shore (Shipowning companies' executives, VTS operators, port agents, coast guard etc) are to blame for false movements.

The main weakness of the human factor is the inadequate knowledge of all the safety rules and regulations as they are implied by the IMO. There are times where the implementation was not right or it was insufficient or some regulations have been missed out. Moreover, the wrong manning of the vessel can result to undesirable situations. That is why it is very important to choose efficiently the crew members and the executives of the shore organizations.

When an accident occurs it has also consequences. The worst is the loss of human lives, which in passenger ships accidents is almost inevitable not to have a casualty. As we have seen in the two case studies that we described earlier in this paper, the passengers are a very sensitive element during an urgent situation. The crew must be well trained to face urgent circumstances and command rightly the passengers, not giving them the opportunities to take initiatives concerning how they are going to react. Furthermore, the pollution of the marine and coastal environment is a great concern. Third comes the economic loss which follows a maritime accident which is usually big and has many aspects.

Overall, as we can assume from the case studies that we presented, it is very difficult to find exactly who to blame for a marine casualty. In most cases, the events are complicated and it takes several time for the investigators to come to an end. Especially when the human factor is involved, the trial may last for years, like in the case of Costa Concordia.

At last, marine safety affect everyone involved with it. The greatest concern is to minimize the number of marine accidents per year. The aim is to ensure safer seas bot

for the thousand tonnes of cargo that are trading by the sea but also for the thousands of passengers and crew members who either work on board or travel. By building a solid future and focusing on improvements concerning the safety regulations, the good training of the crew, the technological improvement of navigation systems on board all vessels, the good management, the number of maritime accidents can be significantly reduced. Of course, there are times when external factors make this inevitable, but always we can hope and try for the best.

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