



## **Lifeboat launch on passenger- and cruise vessels during a heel exceeding 20°**

Assessment if today's regulations are enough to guarantee a safe and complete evacuation in case of an emergency

Diploma thesis in the Master Mariner Programme

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REPORT NO. SK-18/16

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## **Sjösättning av livbåtar på passagerar- och kryssningsfartyg med en lutning över 20°**

Utvärdering om dagens regler är tillräckliga för att garantera en säker och fullständig evakuering vid en nödsituation

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Report no. SK-18/16

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Cover picture:

*Failure to launch a lifeboat during the sinking of M/S Costa Concordia 2012.*

*Retrieved from MONALISA 2.0 Activity 3, Launching and Recovering System Design.*

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# **Lifeboat launch on passenger- and cruise vessels during a heel exceeding 20°**

Assessment if today's regulations are enough to guarantee a safe and complete evacuation in case of an emergency

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## **I Abstract**

Passenger- and cruise vessels today sometimes carry thousands of passengers and crew. It is therefore crucial that the safe and complete evacuation process, by lowering lifeboats and liferafts, is successful during an emergency. This process can however, be unsuccessful or partially unsuccessful if the vessel reaches a heel that exceeds 20° before the evacuation is complete.

This study will firstly look at marine accidents and the regulations of today to try and find out if they in some cases have been inadequate during the launching of lifeboats. Secondly it will show examples of what has or is being done today regarding vessels inability to launch its lifeboats with a heel exceeding 20°. Lastly it will present results from interviews to find out what authorities, companies and people working within the maritime industry stand in this issue.

The result, based on maritime accident investigation reports and documentaries, shows that accidents where the vessels inability to launch its lifeboats when the heel exceeded 20° have occurred. Interviews indicates that this matter is being discussed at some level within the IMO and that there generally is a positive attitude within the industry to improve on this matter.

**Key words:** Lifeboat, launch, heel, list, IMO, SOLAS, LSA, MONALISA, SES

## II Sammanfattning

Passagerar- och kryssningsfartyg kan idag ha tusentals passagerare och besättning ombord. Det är därför avgörande att en säker och fullständig evakuering genom att sjösätta livbåtar och livflottar går att genomföra under en nödsituation. Den här processen kan bli delvis eller helt omöjlig att genomföra om fartyget når en slagsida över 20° innan den är klar.

Den här studien kommer först att se till haverirapporter och dagens regler för att försöka komma fram till om dem i vissa fall har varit otillräckliga under sjösättning av livbåtar. Detta följs av exempel av vad som har gjorts eller görs idag för att öka fartygs förmåga att sjösätta sina livbåtar med en slagsida över 20°. Slutligen presenteras resultat från intervjuer för att komma fram till vad myndigheter, företag och personer som jobbar inom den maritima industrin står i denna frågan.

Resultatet, baserat på haverirapporter och dokumentärer, visar att olyckor där fartygets oförmåga att sjösätta sina livbåtar vid en slagsida över 20° har inträffat. Intervjuer indikerar till att detta problem diskuteras på någon nivå inom IMO och att det generellt inom den marina industrin finns en positiv inställning till att förbättra sig på detta området.

**Nyckelord:** Livbåt, sjösättning, lutning, IMO, SOLAS, LSA, MONALISA, SES

### **III Acknowledgements**

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### **IV Acronyms**

CQD - Come Quick Danger, distress signal used before S.O.S

EU - European Union

Heel - External force on a vessel

IMO - International Maritime Organization

List - Internal force on a vessel

LSA - Life Saving Appliance

MONALISA - Motorways and electronic navigation by intelligence at sea

M/S - Motor Ship

MSC - Marine Safety Committee

NATO - North Atlantic Treaty Organization

RMS - Royal Mail Ship/Royal Mail Steamer

SES - Safe Evacuation System

Significant wave height - Average of the highest  $\frac{1}{3}$  of waves.

SOLAS - Safety Of Life At Sea

SS - Single-screw Steamship

## Table of contents

<b>I Abstract</b>	<b>i</b>
<b>II Sammanfattning</b>	<b>ii</b>
<b>III Acknowledgements</b>	<b>iii</b>
<b>IV Acronyms</b>	<b>iii</b>
<b>V List of figures</b>	<b>vi</b>
<b>1 Introduction</b>	<b>1</b>
1.1 Purpose	2
1.2 Questions	2
1.3 Delimitations	2
<b>2 Background</b>	<b>3</b>
2.1 RMS Titanic	3
2.2 SS Andrea Doria in collision with M/S Stockholm	4
2.3 MTS Oceanos	4
2.4 M/S Estonia	5
2.5 M/S Costa Concordia	6
<b>3 Theory</b>	<b>8</b>
3.1 Legislation within the maritime industry	9
3.1.1 International Maritime Organization	9
3.1.2 Safety of Life at Sea	9
3.1.3 Life Saving Appliance Code	10
3.2 Results from marine accidents research	10
3.2.1 Evidence of issue in launching of lifeboats with a list exceeding 20°	10
3.3 MONALISA – Project to improve maritime safety	11
3.3.1 MONALISA 1	11
3.3.2 MONALISA 2.0	11
3.3.3 Activity 3 – Safer Ships, Safe Evacuation System	12
<b>4 Method</b>	<b>13</b>
4.1 Qualitative interviews	13
4.2 Selection of interviewees	13
4.3 Literature research	15



4.4	<i>Analysis of the obtained information</i> .....	15
<b>5</b>	<b>Results</b> .....	<b>16</b>
5.1	<i>Initiatives for improving maritime safety</i> .....	16
5.2	<i>Interviews and interviewees</i> .....	17
5.2.1	Opinions about the current SOLAS regulations .....	17
5.2.2	Actions today to improve the launching of lifeboats .....	18
<b>6</b>	<b>Discussion</b> .....	<b>20</b>
6.1	<i>Method discussion</i> .....	21
6.2	<i>Validation</i> .....	22
<b>7</b>	<b>Conclusions</b> .....	<b>23</b>
7.1	<i>Further research</i> .....	24
7.2	<i>New solution</i> .....	24
7.3	<i>Other issues with heel exceeding 20°</i> .....	24
7.4	<i>Prevention of list</i> .....	24
	<b>References</b> .....	<b>25</b>
	<b>Appendix</b> .....	<b>28</b>
	<i>Appendix 1 – SOLAS 1914</i> .....	28
	<i>Appendix 2 - Interviews</i> .....	29
	<i>Appendix 3 - SES, Activity 3</i> .....	32

## **V List of figures**

<b>Figure 1. Lifeboat from M/S Estonia.....</b>	<b>5</b>
<b>Figure 2. Failure to launch a lifeboat during the sinking of M/S Costa Concordia 2012....</b>	<b>7</b>
<b>Figure 3. Simulation test done during the MONALISA, SES-project.....</b>	<b>8</b>
<b>Figure 4. Tests done in basin at Centro Jovellanos in Gijon.....</b>	<b>12</b>
<b>Figure 5 Test with straps and sliding pads done during the MONALISA.....</b>	<b>18</b>

# 1 Introduction

A crucial mean of rescue at sea has always been lifeboats. They are sturdy, smaller boats lowered by davits from a ship's side if for some reason it is no longer safe to stay onboard. Today, passenger- and cruise vessels keeps growing in size, some having several thousand passenger and crew in total onboard at one time. It is therefore crucial that all of them can be evacuated safely during an emergency situation. This report will assess whether being able to launch the lifeboats up to a 20° heel is enough to guarantee this. The tilting angle of a vessel will henceforth be described as heel or list. Heel is the result of an external force on a vessel, whereas list is the result of an internal force. Both heel and list are used to describe the tilting angle regardless of external or internal effects.

The sinking of Titanic on the night between 14th and 15th of April 1912 where over 1500 people lost their life led to enquiries in both Britain and the United States. "No other shipwreck in history has left such an indelible imprint upon the public consciousness as that of the RMS Titanic" and it sparked the discussion regarding safety at sea (Lane, 2004). Almost two years later, on 20 January 1914, Safety Of Life At Sea (SOLAS) was signed in London (SOLAS, 1914). Chapter one starts with:

## Chapter I - Safety of Life At Sea

### Article I.

*"The High Contracting Parties undertake to give effect to the provisions of this Convention, for the purpose of securing safety of life at sea, to promulgate all regulations and take all steps which may be necessary to give the Convention full and complete effect." (SOLAS, 1914, p. 67)*

SOLAS has been updated several times over the last hundred years but it all began with a major disaster. According to the present version, passenger- and cruise vessels have to be able to launch their lifeboats with a heel up to 20° and trim up to 10° (SOLAS, 1974, Ch. III).

Following marine accidents such as the sinking of RMS Titanic, M/S Estonia (28 September 1994, 852 dead) (The Joint Accident Investigation Commission. 1997, ch. 8.9) and M/S Costa Concordia (13 January 2012, 32 dead) (Italy's Ministry of Infrastructures and Transports, 2013, p. 5) extensive investigations were launched in order to find out what went wrong. A problem that is consistent with accidents involving these kinds of vessels, is getting the sometimes thousands of passengers and crew into lifeboats and safely launching these in time. Therefore, this is a global and highly relevant problem with the ever increasing number of yearly cruises (Florida-Caribbean Cruise Association, 2017) and it was clear early on that this has been a problem for more than one hundred years.

## **1.1 Purpose**

The purpose of this report is to assess if the current SOLAS regulations regarding lifeboat launching are adequate during substantial heel. Therefore, it will look at examples from maritime accidents where there have been problems with the launching of lifeboats with a heel exceeding 20°. Moreover, this report will evaluate what measures have been taken to address the problem and the opinions of the maritime industry.

## **1.2 Questions**

1. How have today's regulations, of vessels being able to launch lifeboats up to 20° heel, affected the complete and safe evacuation of passengers and crew?
2. What has or is being done today regarding launching of lifeboats during high heel?
3. What do authorities and companies working in the maritime industry think about the current SOLAS regulations regarding launching of lifeboats during substantial heel?

## **1.3 Delimitations**

Being the case that all vessels carry lifeboats, this report focuses on passenger- and cruise vessels. Furthermore, international vessels and accidents will evaluate whether the rules of today are sufficient. However, the questions will be limited to authorities and companies situated in Scandinavia. With the exception of MONALISA (Motorways and Electronic Navigation by Intelligence at Sea) 1 and 2.0, which are projects run by the EU.

## 2 Background

The procedure of launching lifeboats today compared with 1912 when Titanic sank has not changed in principle. The lifeboats have become sturdier, bigger and more reliable. However, they are still being launched with the help of gravity and two davits to hold them over the ship's side (Tiley, 2012). Lifeboats are a crucial mean of rescue and all ships are obliged to carry them. They vary in size and form but all serve the same purpose, to save the lives of passengers and crew when an accident occurs and the ship has to be abandoned.

Following accidents are a few examples where the procedure for launching of lifeboats and the standards and rules surrounding this may have played a role in how many lives were lost.

### 2.1 RMS Titanic

On April 10, 1912 the grandest ship of her time, RMS Titanic began her maiden voyage from Southampton, England to New York, America. She would make two stops on the way in Cherbourg, France and Queenstown, Ireland. However, Titanic was never to reach her final destination and what followed would change life- and regulation at sea forever. Close to midnight on April 14 Titanic collided with an iceberg, resulting in several holes beneath the waterline and flooding of six out of her sixteen watertight compartments. Around thirty minutes after the collision, captain Edward John Smith instructed the wireless operators to send out CQD (Come Quick Danger), the international distress signal at this time. Early on the morning of April 15, less than three hours after the collision, Titanic would rest at the bottom of the Atlantic, taking with her over 1500 men, women and children (Lane, 2004).

At this time Titanic was equipped sixteen lifeboats, enough to carry only 1178 out of her 2207 passengers and crew. This was however, compliant with the present regulations. In addition to this, many lifeboats would be lowered with several empty seats. Only 705 passenger and crew would survive the disaster. "No other shipwreck in history has left such an indelible imprint upon the public consciousness as that of the RMS Titanic". (Lane, 2004).

SOLAS was signed in London 20 January 1914, in response to the sinking of RMS Titanic almost two years earlier (SOLAS, 1914). This made it mandatory for vessels to carry enough lifeboats for a minimum of 75% of all passengers and crew onboard, and in addition pontoon rafts of an approved type for the last 25% (SOLAS, 1914, pp. 111-2). The davits had to be strong enough to lower a lifeboat fully loaded with equipment and persons at a heel up to 15° (SOLAS, 1914, p. 77. Article 49 *Strength and operation of the davits*). Article XII and 49 can be found under appendix 1.

## **2.2 SS Andrea Doria in collision with M/S Stockholm**

In thick fog 25 July 1956 SS Andrea Doria under the command of captain Piero Calamai steamed towards New York City at 22 knots. Due to the fog he had ordered the closing of all watertight doors, reduction of speed, placed extra lookouts and sounded the foghorn. The Doria had a handpicked crew and the most advanced radar system available. At the same time the Swedish liner MS Stockholm had left New York City that same morning and was heading for her homeport Gothenburg, Sweden, with a speed of 18,5 knots. At around 11.10 PM the Andrea Doria collided with the Swedish liner MS Stockholm just off the coast of Nantucket. Stockholm's Ice-cutting, steel reinforced bow sliced through Andrea Doria's starboard side, puncturing three watertight compartments. During the 30 seconds it took for the vessels to collide and separate, 51 people died. Both vessels sent out an S.O.S notifying other vessels and authorities that a collision had occurred. Andrea Doria quickly developed a list of over 20° to starboard, and captain Piero Calamai took the decision to abandon ship (Andrews, 2016).

“Thanks to the legacy of the Titanic disaster over forty years earlier, the Doria was equipped with more than adequate lifeboat capacity for every person onboard”. One problem however would soon become clear, only eight of her lifeboats, all on the starboard side were able to be used. No lifeboats could be launched from her port side due to the substantial list. The lifeboats on her starboard side could only carry 1000 out of her 1663 passenger and crew. Andrea Doria soon radioed a message reading “Need lifeboats - As many as possible - Can't use our lifeboats”. Many vessels came to Andrea Doria's rescue, using their own lifeboats to shuttle the passengers and crew to safety onboard their own vessels. After determining that Stockholm was in no immediate danger, captain Harry Gunnar Nordenson gave the go-ahead to take survivors from Andrea Doria, in total 545. The rest would be rescued by the other vessels that had responded. By 5 AM nearly all survivors were evacuated, the only people left on board were captain Calamai and eleven of his officers. By 5.30 AM, over six hours after the collision, all survivors had finally been rescued and Andrea Doria lay abandoned with a list over 40°. At 10.10 AM she rolled over on her starboard side and sank (Andrews, 2016).

## **2.3 MTS Oceanos**

On 3 August 1991 MTS Oceanos left East London, South Africa for Durban with 571 passengers and crew, under the command of captain Yiannis Avranas. Launched in 1952 the vessel was nearing 40 years of age and quite run down. With increasingly strong winds and bigger waves Oceanos began to take on water through pipes running across her watertight compartments. It soon became clear that the vessel would eventually sink (Smith, 2010).

Oceanos had eight lifeboats, four on each side. At 1.30 AM the last lifeboat on the starboard side was launched. Entertainers and cruise director now led the passengers to the port side and started to board the last three remaining lifeboats. The crew would soon however make an awful discovery; “The ship was now heeling over so far, that the lifeboats would not slide down. They were just kind of stuck on the side of the ship. Then we realised, right, we got no more lifeboats and we got a couple of hundred people still left onboard”. Miraculously no one died when MTS

Oceanos sank, though an estimated 225 people were saved by using harnesses to hoist them up onto helicopters sent there mainly by the South African air force in a major rescue operation lasting seven hours. At 3.30 PM the following day Oceanos finally rolled over and sank. (Smith, 2010).

## 2.4 M/S Estonia

The sinking of Estonia was one of the worst maritime disasters in peacetime history, not only for Sweden, Finland and Estonia but the entire world (Peacetime shipping disasters – Timeline, 2012). It is the disaster that “has taken the greatest toll of human life in the Baltic Sea in times of peace” (The Joint Accident Investigation Commission, 1997, Preface).

On 27 September 1994 Estonia left Tallinn, Estonia bound for Stockholm, Sweden. At 1.00 am on September 28 a large metallic bang was heard, only ten minutes later the bow visor would separate from the bow, also pulling the ramp fully open. Estonia very rapidly took on large amounts of water onto the open car-deck, she slowed down and took on a substantial list. At 1.22 am a Mayday was transmitted, it was received by 14 ship- and shore-based stations (The Joint Accident Investigation Commission, 1997, ch. 1).

Onboard the vessel panic spread as passengers tried to make their way towards higher decks and lifeboats, many were trapped in their cabins and were unable to save themselves (The Joint Accident Investigation Commission, 1997, ch. 1). Estonia was equipped with ten lifeboats but the crew was not able to launch a single one of them, the main reasons are believed to have been the rapidly increasing list and lack of time. Nine lifeboats would break off and float to the surface when she sank (*see picture 1*) (The Joint Accident Investigation Commission, 1997, ch. 17.7.1).



Figure 1. Lifeboat from M/S Estonia. (The Joint Accident Investigation Commission, 1997, ch. 17.7.1). Reprinted with permission.

Approximately 300 people made it onto the open decks where the crew distributed lifejackets, many were washed into the sea and others jumped. Around 160 made it onto liferafts and capsized lifeboats. Out of these, 104 were rescued by helicopters and 34 by other vessels (The Joint Accident Investigation Commission, 1997, ch. 20).

The prime ministers of Sweden, Finland and Estonia made the decision to set up a Joint Accident Investigation Commission on 29 September 1994, only one day after the accident. In December 1997 the report was delivered. 852 out of 989 died (The Joint Accident Investigation Commission, 1997, Introduction). Only 137, about 14% ( $137/989 \approx 0.1385$ ) survived the accident.

## **2.5 M/S Costa Concordia**

Almost to the date, one hundred years after the sinking of RMS Titanic, history would repeat itself (Tiley, 2012). Costa Concordia, carrying thousands of passengers, sank with the loss of life (Italy's Ministry of Infrastructures and Transports, 2013, p. 3). Following the sinking of Costa Concordia, Italy's Ministry of Infrastructures and Transport launched a marine casualty investigation leading up to a final report (Italy's Ministry of Infrastructures and Transports, 2013). In 2015 captain Francesco Schettino was sentenced to 16 years and 1 month in jail for manslaughter, causing a shipwreck, abandoning ship before passengers and for lying to port authorities (BBC, 2017).

On 13 January 2012 Costa Concordia left the port of Civitavecchia en route to Savona, Italy, with 4229 passengers and crew onboard. Captain Francesco Schettino chose to navigate his vessel very close to the island Giglio at the speed of 15.5 knots. At 9.45 PM the vessel would hit the "Scole rocks" just outside the island, resulting in a 53 m breach underneath the waterline on her port side. The vessel lost propulsion almost immediately and drifted back towards the island due to favourable wind and current, she would later come to rest just outside the port. (Italy's Ministry of Infrastructures and Transports, 2013, pp. 3-4).

Costa Concordia had a total of 26 lifeboats and 69 liferafts, out of these 23 lifeboats and 6 liferafts were able to be launched in order to save passenger and crew. The lifeboats drove to shore and liferafts were towed to the ferry "Aegilium" which took the survivors onboard. Approximately two thirds of the 4229 passengers and crew were saved by life saving equipment belonging to the Concordia (Italy's Ministry of Infrastructures and Transports, 2013, p. 26)

Several passengers and crew were not able to abandon the ship in time with lifeboats or liferafts, due to the fact that they were not gathered in time. They had to leave the vessel on their own, using one of the two embarkation ladders, one on the bow and one close to the stern. These ladders were in compliance with SOLAS but not fully usable due to the substantial heel exceeding 20° (Italy's Ministry of Infrastructures and Transports, 2013, p. 26).



As previously mentioned in this report, lifeboats must be able to be launched with a list up to 20°. In this case, the operation to launch the lifeboats began around 11 PM and the list was already close to 20°, only 11 minutes later it would reach 30°. This means that during the operation the list would increase more and be well over the limit. Resulting in 3 lifeboats being unable to be launched and equipment being used way beyond what it had been designed for (Italy's Ministry of Infrastructures and Transports, 2013, p. 88).



*Figure 2. Failure to launch a lifeboat during the sinking of M/S Costa Concordia 2012 (MONALISA 2.0, Activity 3, Launching and Recovering System Design). Reprinted with permission.*

One marine underwriter at Lloyd's of London insurance market said "The frightening thing is how quickly the ship went on its side. If it had been out to sea there would have been a massive loss of life," (Analysis: Italy disaster shows Titanic lifeboat issues linger, 2012, 20 January). One hour after the Launching was initiated, around 12 PM, the list was 40° and it would reach 80° during the rescue operation (Italy's Ministry of Infrastructures and Transports, 2013, p. 5).

### 3 Theory

A ship's lifeboat launching equipment is not designed to work during a heel exceeding  $20^\circ$ . When this occurs, launching a lifeboat becomes a serious problem and it could dangerously damage the davits (SES, Launching and Recovering System Design, ch. 4.2). It may not be possible to get the lifeboat clear of the ship's side (see *picture. 2*) and the friction between the lifeboat and ship's side in combination with the angle may prevent it from sliding down (see *Picture. 3*).

There are global rules and regulations concerning the safe launching of lifeboats in accordance with the International Maritime Organization (IMO) and SOLAS, but also other recommendations that further increases a vessels ability to launch its lifeboats such as the MONALISA project.

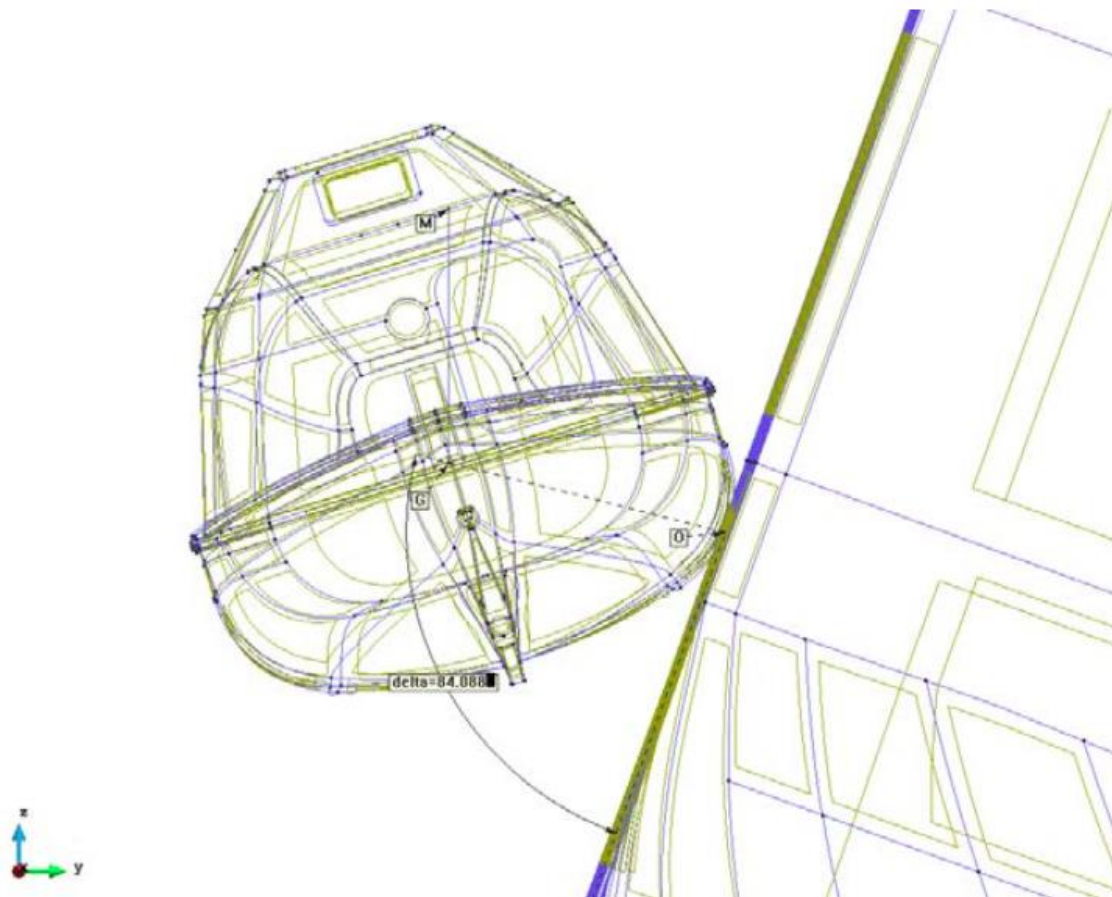


Figure 3. Simulation test done during the MONALISA, SES-project. (SES, System Validation). Reprinted with permission.

### **3.1 Legislation within the maritime industry**

The relevant maritime legislations for this report will be presented in three steps. Initially, the IMO will briefly be presented to give an understanding of the global effect maritime rules and regulations pose. Secondly, the SOLAS convention will be presented where the rules and regulations that will be assessed in this report can be found. Lastly, the LSA - Code with the specific rules and regulations evaluated in this report will be presented to understand the complete structure of maritime legislations.

#### **3.1.1 International Maritime Organization**

The IMO is part of the UN's specialized agency which is responsible for the safety, security and prevention of marine pollution in the maritime industry. The IMO consists of membership states, based on countries around the world with a fleet of ships, that want to abide by the rules and regulations as well as have a vote when new proposals arise. Therefore, IMO is the global framework for shipping industry, responsible for creating the rules and regulations that all the membership states must comply with. Currently there are 173 membership states within the IMO and each flag state has the responsibility to ensure that every ship under their flag fulfils the demands of SOLAS. Within IMO there are several conventions adopted over the years, one of them being the international convention for SOLAS. (IMO, 2017). Furthermore, within IMO, the highest technical body is the Marine Safety Committee (MSC) which consist of all 173-member states. The MSC's responsibility is to "consider any matter within the scope of the Organization concerned with aids to navigation, construction and equipment of vessels, manning from a safety standpoint, rules for the prevention of collisions, handling of dangerous cargoes, maritime safety procedures and requirements, hydrographic information, log-books and navigational records, marine casualty investigations, salvage and rescue and any other matters directly affecting maritime safety". The MSC adopts amendments to conventions, for example SOLAS, and includes all member states for the ratification of regulations. (IMO, Structure of IMO, 2017)

#### **3.1.2 Safety of Life at Sea**

As previously mentioned SOLAS was adopted by the IMO for the first time 1914, second in 1929, third in 1948, fourth in 1960 and lastly the current one often referred to as SOLAS, 1974 as amended. There have been numerous changes and amendments since (IMO, 2017). SOLAS is the convention containing minimum standards for construction, equipment and operation of ships regarding safety. SOLAS is divided into different chapters, however this report will only handle chapter III, life saving appliances and arrangements. Chapter III regulates the rules regarding lifeboats and their capacity, means of launching and handling (SOLAS 1974, 2017).

### **3.1.3 Life Saving Appliance Code**

The Life Saving Appliance Code (LSA - Code) is chapter III in SOLAS and entered into force on 1 July 1998, chapter IV regulates survival crafts (LSA - Code, 1998). SOLAS is the framework for safety and the LSA - Code defines the different requirements in more specific detail. For example, SOLAS defines how many lifeboats a ship must have and the LSA - Code discloses the way lifeboats shall be designed, dimensions and capacity (SOLAS 1974, as amended)

According to the current LSA - Code, lifeboats shall be approved to carry a maximum of 150 persons (LSA - Code, 1998). However, there are exceptions to this regulation for the cruising industry, if the lifeboats can demonstrate the same level of safety as the requirements in the LSA - Code dictates. As a result, new lifeboats have been accepted with a capacity of up to 370 persons each, weighting up to 45 tonnes fully loaded (The Royal Institution of Naval Architects). Moreover, the LSA - Code states that gas carriers, oil- and chemical tankers shall be able to launch their lifeboats with a heel exceeding 20° on the “lower side” of the vessel facing towards the water, in accordance with International Convention for the Prevention of Pollution from ships, 1973 as modified by protocol of 1978. (LSA - Code, 6.1.1.1, 6.1.1.2). There are parts of the regulations specially adapted to some vessel types for the minimum requirements set by the authorities. Furthermore, it should be noted that the launching of lifeboats shall not be dependent on any stored power from the vessel itself. Meaning the lifeboat shall be independently launched with gravity force alone or externally stored mechanical power. (LSA - Code, 6.1.1.3). It should also be noted that recovering of a lifeboat shall be able to be done with mechanical means by the crew. Meaning no power dependent on the ship’s power shall be crucial for the recovery. Handheld winching is the only mechanical way of recovering a fully loaded lifeboat, this is heavy and takes time (LSA - Code, 6.1.1.3). In conclusion, the passenger- and cruise vessels must be able to fully evacuate the ship within 30 minutes from the abandon ship signal is sounded (LSA - Code, Regulation 21, ch. 1.3).

## **3.2 Results from marine accidents research**

Marine accident investigation reports and documentaries about accidents at sea determine that there have been several cases where the launching of lifeboats was affected by the ship’s list or heel. The sinking of RMS Titanic was not found to be one of these cases. It was however the trigger for regulations of safety of life at sea, SOLAS (Lane, 2004)(SOLAS, 1914). The accident demonstrated the need of regulations in order for vessels to carry enough lifeboats for everyone onboard. To the new regulations, articles were added about the circumstances in which these launching systems had to work. After 1914 the new regulations made it mandatory for vessels to be able to launch lifeboats with a list up to 15° (SOLAS, 1914, p. 77. Article 49 *Strength and operation of the davits*).

### **3.2.1 Evidence of issue in launching of lifeboats with a list exceeding 20°**

SS Andrea Doria’s collision with M/S Stockholm and the sinking of MTS Oceanos shows two examples where the list directly affected the launching of lifeboats. Both Andrea Doria and

Oceanos did for different reasons take on large amounts of water, resulting in a substantial list which made them unable to launch all lifeboats. Neither of these did however result in any further loss of life due to assistance received from other ships or helicopters (Andrews, 2016)(Smith, 2010).

The sinking of M/S Estonia and later M/S Costa Concordia are accidents that resulted in major loss of life. Both were followed by marine casualty investigations which shows that the list over 20° prevented the launching of some lifeboats. The lack of time and substantial list resulted in Estonia not being able to launch a single of her 10 lifeboats (The Joint Accident Investigation Commission, 1997, ch. 17.7.1). Costa Concordia was unable to launch 3 out of her 26 lifeboats due to the substantial list and late evacuation (Italy's Ministry of Infrastructures and Transports, 2013, p. 26). If or how many lives are believed to have been lost due to this are not stated in any of the reports.

### **3.3 MONALISA – Project to improve maritime safety**

MONALISA is a partly sponsored project by the EU and have been launched in two stages. The project aims to improve maritime safety and transport (Swedish Maritime Administration, 2012). Following are the two projects described, with more focus on MONALISA 2.0 where the part relevant for this project is found.

#### **3.3.1 MONALISA 1**

MONALISA 1 ran between September 2010 and December 2013 with a budget of 22.4 million euros. It's lead partner was the Swedish Maritime Administration and it aimed to improve navigation, maritime safety and security in the Baltic region among many other things (Swedish Maritime Administration, 2012).

#### **3.3.2 MONALISA 2.0**

MONALISA 2.0 continued to work on what was learned from MONALISA 1, also led by the Swedish Maritime Administration. The project ran from 2012-2015 with a budget of 24 million euros. It consists of four acts that all contribute to improving safety and efficiency of the maritime transport. Their objectives are to strengthen the efficiency, capacity, flexibility, predictability, security, safety and the environmental performance of maritime transport, while simultaneously reducing the administrative burden of the maritime sector. Following are the four acts MONALISA consists of. With Act. 3 being the relevant one this report regarding Safe Evacuation System (SES), described more in detail below. Specifications for SES can be found under Appendix 3.

- Act. 1 – Sea Traffic Management Operations and Tools
  - Act. 2 – Sea Traffic Management Definition Phase Study
  - Act. 3 – Safer Ships
  - Act. 4 – Operational Safety
- (Swedish Maritime Administration, 2012)

On the 10-11 November 2015 the final conference for MONALISA 2.0 was held at Lindholmen in Gothenburg, Sweden. Around 300 people from 20 different countries attended and on the first day safety was in focus. Here they presented following progress: “A prototype for safe life boat launching at heel over 20 degrees tested in the basin at Centro Jovellanos in Gijón” among many other things ([Laursen](#), 2015).

### **3.3.3 Activity 3 – Safer Ships, Safe Evacuation System**

This activity aims to improve safety on board large passenger vessels. Allowing for a more efficient rescue operation. During the evacuation “most existing lifeboats cannot be safely launched if the vessel is sinking with a heel over 20° to the opposite side” ([Laursen](#), 2015). The solutions presented here are based on improving existing systems and technologies by installing accessories to improve function.

The SES is as previously mentioned one of MONALISA 2.0’s projects and it focuses on what this report is about, the problems that appears with launching lifeboats when a damaged vessel is sinking with a list exceeding 20°. The SES project presents two cost beneficial solutions that can be applied to different types of vessels on their equipped systems with minimal adaptations. Both solutions shall be able to safely launch the lifeboats at heel conditions higher than 20° which is the current SOLAS rule. The solution should mainly be able to work on the ship’s side facing up from the water where there is a higher risk of not launching the lifeboats, referred to as the “upper side” in this report. This is also considered to be the safest side to launch a vessel’s lifeboats (SES, System Validation, ch. 4).



*Figure 4. Tests done in basin at Centro Jovellanos in Gijón (SES, launching and recovery system design).  
Reprinted with permission.*

## **4 Method**

For this report a qualitative research was chosen since it was believed to be the most relevant method. Qualitative research is based on analysing a specific topic and area. The data was obtained from analysing semi structured interviews with organizations within the maritime industry, as well as literature research from marine investigations reports and scientific documents from the MONALISA, SES project (Bryman, 13).

### **4.1 Qualitative interviews**

To obtain information from interviews a semi structured method was chosen. Questions with a general subject were prepared for the different organizations. This gave the possibility to form specific questions for each organization, and also opened up for discussions and their subjective opinions (Bryman, 13).

The interviews were performed in person with one or more representatives from each organization. They were held at locations chosen by the representatives to facilitate the process and for increased participation. However, if there was no opportunity to meet in person, some of the interviews were performed over telephone or email. Furthermore, for an ethical purpose considering this is a relatively small industry, it was presented that anonymity would be given and the results would be presented as representatives of their company. Initially, a brief presentation of the study was given for the interviewees for a better understanding of the questions. The questions were formed so there could be an open discussion with the interviewees giving both facts and subjective opinions (Denscombe, 2016)

### **4.2 Selection of interviewees**

Interviews were based on purposive sampling; the selection was based on people working within the maritime industry with a direct or indirect connection. The intention was to obtain a wide variety of information from different perspectives (Bryman, 13). This led to contacting the following parties:

- Swedish Shipowners' Association
- The Swedish Transport Agency
- Lecturer at Chalmers with a PHD in shipbuilding technology
- MONALISA – SES project, activity 3
- Classifications societies
- Shipping companies, active seafarers
- Manufacturers of davits



Out of the previously mentioned the following were interviewed:

- Swedish Shipowners' Association
- The Swedish Transport Agency
- Lecturer at Chalmers with a PHD in shipbuilding technology
- MONALISA – SES project, activity 3
- Shipping companies, active seafarers
- Classification societies

All the participants for interviews played a significant role working with the regulations as well as life saving equipment in first hand. For a better understanding of how the different organizations presented are connected to our project, a brief description will be presented below:

### **Swedish Shipowners' Association**

The Swedish Shipowners' Association is part of the Swedish delegation to IMO and has therefore knowledge about new legislations discussed on the IMO agenda. Their mission is to promote issues globally and to increase the knowledge about the Swedish shipping industry (Swedish Shipowners' Association, 2018).

### **Lecturer with a PHD in shipbuilding technology**

An interview of a lecturer in shipbuilding technology at Chalmers university of technology. He has been involved in calculation scenarios surrounding the sinking of m/s Estonia and has knowledge of both legislation and ship stability.

### **The Swedish Transport Agency**

The Swedish Transport Agency is the supervisory authority responsible for making Swedish shipping safer. Some of their tasks being; issuing certificates, Swedish rules and regulations and documenting accidents and incidents. Moreover, the Swedish Transport Agency is part of the Swedish delegation to IMO and participate in meetings (The Swedish Transport Agency, 2018).

### **MONALISA - SES project**

MONALISA 2.0 is a very relevant project for this report. During the work with SES they had a company in Spain, that also manufacture davits, to perform tests regarding the launch of lifeboats during different heeling angles. This company was contacted through mail.

### **Classifications societies**

The classification societies role is, among other, to examine and approve life saving equipment. Their judgement is based from the IMO's rules according to SOLAS and the LSA – Code.



## **Shipping companies**

Active members onboard Swedish vessels as well as safety representative from respective shipping companies were contacted. Working actively with life saving equipment, including training with launching of lifeboats onboard vessels. These companies have many vessels operating in the Baltic sea, in the same area where Estonia sank, increasing the relevance of their opinions for this project.

### **4.3 Literature research**

No scientific papers were found during the research since there seems to be limited scientific research about launching of lifeboats during heel. However, the result from several scientific documents regarding the project MONALISA, were obtained and assessed. Another source of information was the marine accidents investigation reports involving the evacuation of vessels, where the launching of lifeboats posed as an issue. The reports are a very significant source because they show how the launching of lifeboats in real scenarios have been an issue. Further information was obtained from rules and regulations relating to launching of lifeboats, which the industry must follow. Additional research involved selected documentaries and news articles.

### **4.4 Analysis of the obtained information**

All information is based on qualitative data, obtained through interviews and research. During the interviews one author was dedicated to documenting the discussions and answers obtained, whilst the other presented the questions. The data was then composed into a conclusion. This conclusion was then analysed, and colour coded, to find common statements and opinions. The result of this analysis was compiled under two subtitles (Denscombe, 2016)(Bryman, 2013).

## 5 Results

The results of this study will be presented in two steps. First, the actions and initiatives taken today to improve the launching of lifeboats during substantial heel. Second, the results from interviews made with authorities, companies and people working within the maritime industry are presented, in order to find out where they stand in regard to the issue of launching lifeboats during a substantial.

### 5.1 Initiatives for improving maritime safety

Within MONALISA 2.0 there was the project SES where they investigated other methods to ensure that lifeboats could be launched at a 20° heel or higher. Two solutions were presented in their official report, both methods were based on the possibility to improve existing systems. One for the davits so that the lifeboat can be lowered to the vessel's side without getting stuck on deck or in the railing. The second solution gives the lifeboat less friction towards the hull side therefore reducing the risk of being stuck along the way.

The solution for davits is 2-3 straps attached from the vessel deck, with clamped devices (see picture. 4), to the lifeboat itself. When the davits move, either tilting conventional or telescopic movement, the straps tighten to keep the lifeboat clear from ships deck or railings.

The solution for decreasing friction between the lifeboat and the vessel's hull is sliding pads mounted on the lifeboats hull which will be placed without damaging the hull nor affecting the navigational capability of the lifeboat. The sliding pads are for the lifeboats situated on the “upper part” of the heeled vessel. To ensure a safe passage down the hull without getting stuck, nor the risky operation of heaving it back up.



*Figure 5. Test with straps and sliding pads done during the MONALISA, SES project (SES, pilot application). Reprinted with permission.*

The SES - project studied recent accidents and concluded that increasing the capability to launch lifeboats up to 30° is sufficient. This is a 50% increase from the current regulations of

20°. Even though the new system has the capability to exceed 30°, nonprofessional individuals would not be able to embark into the lifeboats (SES, Pilot Application)

## **5.2 Interviews and interviewees**

Analysis of the answers received from interviews conducted with authorities and relevant persons chosen to obtain professional and adequate information for this project. Following are the seven different parties contacted in order to discuss the launching of lifeboats with a list exceeding 20°. The full interviews can be found in appendix 2.

1. Swedish Shipowners' Association
2. Swedish shipping companies
3. lecturer with a PHD in shipbuilding
4. Swedish Transport Agency
5. Classifications societies
6. MONALISA

The response from different parts of the industry we contacted have been positive, the majority replied and thought this was a good and relevant question evaluate.

### **5.2.1 Opinions about the current SOLAS regulations**

The Swedish Shipowners' Association stated that discussions regarding the launching of lifeboats are most certainly on the IMO's agenda at some level. On the contrary, it was the Swedish Transport Agency's opinion that this is not a subject of discussion.

When it comes to today's SOLAS standards, The Swedish Shipowners' Association had no opinion whether today's standard of 20° is enough. On the other hand, The Swedish Transport Agency finds that it is sufficient to conduct tests according to current SOLAS regulations. However, this opinion was not shared by the lecturer in ship building technology whom stated that many vessels will sink with a list exceeding 20°. Close to all passenger vessels; especially those with open car decks, that dramatically increases the free surfaces effect and thus effecting the stability of the vessel even more, will at some point completely capsize before sinking. Even though the watertight compartments go all the way through a vessel, from port to starboard, the chance of a passenger vessel sinking without a list is close to nil. When all stability is lost, some external force will push the vessel onto one of its sides. In accordance with the lecturer, the opinion of MONALISA was that; "It is important to look at the evolution of stability of a vessel before sinking, the longer it can stay below 20° heel the higher the chance of a successful evacuation". It is their opinion that this is an issue that should be discussed within the industry and IMO, since technology has developed more than the regulations. Therefore, regarding today's regulation of 20°, MONALISA's opinion is that; "it is never enough if just one more life can be saved".

According to the the Swedish Transport Agency vessels are unable to launch their lifeboats with a heel exceeding 20°. It results in too much stress on the equipment which is not designed

to work during these conditions and it is too complicated for the passengers and crew to reach their evacuation stations. The Swedish shipping companies did not want to discuss whether today's rule of 20° is enough, fortunately they have no experience in this matter and did not want to speculate. Their vessels and equipment are constructed and approved according to today's regulation and they presume it will work and cannot do more than to continue to conduct drills during "normal" conditions.

### **5.2.2 Actions today to improve the launching of lifeboats**

The SES activity in the MONALISA project used pictures from Costa Concordia and other accidents where launching of lifeboats failed. This was sufficient enough to motivate the funding for research to the problem with ships only being able to launch lifeboats with a heel up to 20°. According to the Swedish Shipowners' Association the IMO is open for suggestions to improve safety. "It does not have to be as a reaction from another accident as long as there is an economically sustainable solution presented". MONALISA has with the SES project managed to come up with various solutions that could be deployed without a major cost. This however, should be a decision from the owners considering health, safety and insurances cost reductions. They do have some experience in this matter during projects for NATO and Coast guard vessels that have higher LSA requirements than commercial vessels. There seems to be a positive attitude towards improving rules in regard to safety, especially after accidents such as Costa Concordia where a lot of media coverage was given, the companies focus even more on safety. Similarly, The Swedish Transport Agency's opinion is that presenting a fully working evacuation alternative that is cost effective and not too complicated would be a good approach. It is easier to implement a temporary adoption on already working systems within shipping companies and IMO. On the contrary to changing the rules and regulation which takes several years, and it has to get on the MSC and IMO's agenda. However, after the sinking of Costa Concordia there have been a lot of discussions on how to prevent ships from ever reaching 20° list if damaged. This opinion was shared by the lecturer in shipbuilding technology; that today the prevention of ships from reaching that kind of list is more discussed. Although you should not "put all your eggs in the same basket" and looking into the launching system and the rules surrounding this is also vital. It is unusual for shipbuilders to do calculations on the amount of time the ships are expected to have before reaching this critical angle. Neither are there rules making it mandatory to know this specific type of information, although the lecturer has had some previous experience within this area.

Today lifeboats are generally placed lower on the ship's sides. Launching the lifeboats from a lower point when the vessel suffers from a list makes the sideways distance it has to travel shorter and thus making it easier to launch them. This does however give the lifeboats on the lower side, leaning towards the water a shorter amount of time to launch before it reaches the water and it will be too late. It is the opinion of the lecturer in shipbuilding technology that this is, anyway, a better solution.

Lastly according to The Swedish Shipowners' Association there is within IMO a lot of politics, some countries have veto right. With over 170 states that must agree it takes time but once the rules are passed, it is mandatory for all the membership states. This is a large portion of the entire world which makes it very impactful.

## 6 Discussion

With the ship heeling 20° or more the obvious choice of launching lifeboats safely would be on the “upper side”. This is however, the side most affected by the vessel’s heel during launching of lifeboats.

Evidence gathered from marine accidents investigations reports and documentaries clearly shows, on several occasions, that a ship’s inability to launch its lifeboats with a list exceeding 20° prevented the safe and complete evacuation of passengers and crew. Marine accidents investigation reports and documentaries does not state that this fact directly resulted in any loss of life. This would only be speculation, it is however, most likely the case. Although extensive investigations have been launched following major accidents such as Estonia and Costa Concordia. The improved but aged system, of lowering lifeboats with davits, is still being used today for evacuating vessels and has been around since RMS Titanic. Improving the launching of lifeboats is however, clearly being worked on through projects such as MONALISA and does according to the interview with the Swedish Shipowners’ Association seems to be discussed within the IMO at some level.

As mentioned before, adopting new regulations within the IMO is a long process to accomplish. The regulations have however been changed before from 15° to 20°. Requirement for adopting a new rule within IMO involves all the 173-member states, as well the veto right from a selected few. The result of this is a very slow-going process and it takes several years before a proposal gets adopted. The maritime industry is generally reactive, and this report found no major changes have been made regarding the operation and construction of the lifeboats and davits. The easiest way to improve the launching of lifeboats would be to present a cost affective method that could be implemented on current systems, like the solutions presented in the MONALISA, SES project.

According to the LSA-code gas carriers, oil- and chemical tankers and have special regulations when it comes to launching lifeboats. The regulation state that these types of vessels shall be able launch their lifeboats during a list equal or higher than 20°, on the “lower side” of the vessel facing towards the water. However, there are no similar regulations similar applying for passenger- and cruise vessels which is worth noticing as it shows that ship specific regulations are possible. It is possible that, on passenger- and cruise vessels where there is a substantial amount of people in need of evacuation, such regulations would be favourable. Considering the increasing demand on the cruising industry as well as higher passenger numbers on larger vessels the regulations of today may not be adequate. The fact that a passenger- or cruise vessel shall be able to evacuate all passengers and crew within 30 minutes of sounding the abandon ship signal without any regulation stating it has to stay below 20° list for any amount of time. This is a very short period of time to evacuate today’s large passenger- and cruise ships, considering that most vessels will have a greater angle of heel than 20° before sinking.

Information obtained through interviewing companies within the maritime industry, indicates that there is a positive attitude towards improving a ship's ability to launch its lifeboats and thus improving the safety for passengers and crew. Some improvements can be achieved through solutions fitted to existing systems as demonstrated in MONALISA's SES project. Containing the maritime safety of evacuating passenger ships and cruise ships explaining the problem with current systems and equipment and proposing new concrete suggestions that could be applied on existing systems and improve the safe launching. Moreover, these solutions should be cost beneficial as this will increase the shipping companies interest for improving life saving equipment.

One new problem was found that was consistent during the accidents presented in this report; the difficulty for passengers and crew to move around the vessel during a substantial list. If a 30-metre-wide vessel has a list of 20°, the difference in height between the lower- and upper side will be more than 10 metres. This makes it hard, especially for the more senior passengers and disabled, to move to their muster- and lifeboat stations. This is supported by the SES – project where it is stated that nonprofessional individuals would not be able to embark the lifeboats with a list exceeding 30°.

## **6.1 Method discussion**

The methods chosen for this paper worked with various results. Finding scientific articles related to this subject have been challenging. Instead the focus has been on finding relevant accidents and their marine accident investigation reports or documentaries describing the course of events, particularly regarding the evacuation and launching of lifeboats. These are however, considered as valuable sources of information since they are based on real accidents.

Semi structured interviews were chosen for the report, so the interviewees' subjective opinion could be presented. This results in better qualitative data on the contrary to structured interviews where the participants are more guided with strict questions. The semi structured method, including subjective opinions, is beneficial since it allows for contacting different organizations within the industry to obtain similar answers, thus increasing the validity of information. However, the disadvantage of qualitative data is the increased degree of difficulty to analyse the obtained information. The selection of interviewees was carefully assessed to include relevant organizations regarding the launching of lifeboats. However, this necessary selection resulted in interviews with only one representative from each organization, responsible for this specific area. This resulted in the decision of anonymity for the participants. Further it was believed that the anonymity would increase the validation since the participants could disregard their personal involvement. The overall response was positive regarding this decision.

To increase the validity of this report, the response from missing parties should have been obtained. It is hard to determine the reason for their defaulted participation, whether it was the lack of interest or relatively short timeline to arrange for interviews. However, during the

interviews performed, suggestions for more parties to contact were given. Increasing the number of parties interviewed for this report.

## **6.2 Validation**

The result from interviews went through triangulation, a process used for validation of information. The intention of triangulation is to assess the validation of obtained information by comparing it to other sources. To achieve different perspectives and determine the credibility of the data (Denscombes, 2016).

The documentation's reliability was based on; when the documentation was published, who the publisher is and who wrote it. The information's credibility was evaluated from how many times the documents had been used and referred to, all according with the Denscombes (2016) recommendations.



## 7 Conclusions

A vessel's inability to launch its lifeboats with a list exceeding 20° is a serious issue and evidence to support this have been presented in the report. Following are the conclusion based on the questions and purpose of this report.

***How have today's regulations, of vessels being able to launch lifeboats up to 20° heel, affected the complete and safe evacuation of passengers and crew?***

Results acquired by reading marine accident reports, watching documentaries and conducting interviews clearly shows that there have been several accidents where the ability to only launch lifeboats with a heel up to 20° affected the evacuation. Thus, limiting the number of lifeboats launched and that this very likely resulted in loss of life. This means that today's regulations in some cases have been inadequate.

***What has or is being done today with regard to launching of lifeboats during high heel?***

Launching of lifeboats is being discussed at some level within IMO and due to projects, such as MONALISA 1 and 2.0 there seems to be a desire to improve on this matter. The MONALISA 2.0, SES project has through extensive testing and research developed two solutions applicable to current life saving equipment with minimum adaptation. This was the only project focused on the launching of lifeboats that the research for this study found. For further development of lifeboat launching to emerge, there has to be an initiative from the maritime industry as a collaboration between authorities and shipping companies.

***What does authorities and companies working in the maritime industry think about the current SOLAS regulations regarding launching of lifeboats during substantial heel?***

Through interviews conducted for this report, the conclusion made is that there generally is a positive opinion to improve on a vessel's ability to launch its lifeboats with a list exceeding 20°. "One life lost is one life too many" and even though new regulation through IMO takes a lot of time, companies may have to try and improve beyond today's regulations.

### **7.1 Further research**

During the project, topics connected to the problem with launching of lifeboats during a list exceeding  $20^\circ$  were found and some of these could be looked further into.

### **7.2 New solution**

Initially this report intended to look at a new solution for launching of lifeboats. However, due to the delimitations of this project as well as the relatively short timeline this had to be excluded. Although, further research could be done in order to find a new solution to the problem regarding launching of lifeboats.

### **7.3 Other issues with heel exceeding $20^\circ$**

Launching a lifeboat when the ship suffers from a list is not the only problem. Making it possible for passengers and crew to move across the vessel into position to board the lifeboat is a challenge itself, this could be looked further into.

### **7.4 Prevention of list**

Research is and have been carried out in order to prevent ships from reaching  $20^\circ$  list. Double bottom hull is one way and a relatively new concept called Safe Return to Port is a way to try to prevent ships from reaching this high list. This is something that could be looked further into.

## References

- Andrews, E. (2016). The sinking of Andrea Doria. Retrieved from URL <http://www.history.com/news/the-sinking-of-andrea-doria>
- BBC. (12 May 2017). Costa Concordia captain's sentence upheld by Italy court. Retrieved from URL <http://www.bbc.com/news/world-europe-39903968>
- Bryman, A. (2011). Samhällsvetenskapliga metoder. Chalmers library Lindholmen.
- Denscombe, M. (2016). *Forskningshandboken: För småskaliga forskningsprojekt inom samhällsvetenskaperna*. (3. uppl.). Chalmers library Lindholmen
- Florida-Caribbean Cruise Association. (2017). Cruise Industry Overview - 2017 Retrieved from URL <http://www.f-cca.com/downloads/2017-Cruise-Industry-Overview-Cruise-Line-Statistics.pdf>
- International Convention for the Safety of Life at Sea (SOLAS). (1974). Retrieved from URL [http://www.imo.org/en/About/conventions/listofconventions/pages/international-convention-for-the-safety-of-life-at-sea-\(solas\),-1974.aspx](http://www.imo.org/en/About/conventions/listofconventions/pages/international-convention-for-the-safety-of-life-at-sea-(solas),-1974.aspx)
- IMO. (1914). Text of the Convention for the Safety of Life at Sea. Retrieved from URL <http://www.archive.org/stream/textofconvention00inte#page/112/mode/2up/search/davit>
- IMO. (2017). *International convention for Safety of Life at Sea(SOLAS) 1974: Adoption: 1 November 1974; Entry into force: 25 May 1980* Retrieved from URL [http://www.imo.org/en/About/conventions/listofconventions/pages/international-convention-for-the-safety-of-life-at-sea-\(solas\),-1974.aspx](http://www.imo.org/en/About/conventions/listofconventions/pages/international-convention-for-the-safety-of-life-at-sea-(solas),-1974.aspx)
- IMO. (2017). *History of IMO (International Maritime Organisation)* Retrieved from URL <http://www.imo.org/en/About/HistoryOfIMO/Pages/Default.aspx>
- IMO. (2017). History of SOLAS (The International Convention for the Safety of Life at Sea). Retrieved from URL <http://www.imo.org/en/KnowledgeCentre/ReferencesAndArchives/HistoryofSOLAS/Pages/default.aspx>
- IMO. (2017). Structure of IMO. Retrieved from URL <http://www.imo.org/en/About/Pages/Structure.aspx>

Italy's Ministry of Infrastructures and Transports. (2013). Costa Concordia Marine Casualty on January 13, 2012. Retrieved from URL [http://3kbo302xo3lg2i1rj8450xje.wpengine.netdna-cdn.com/wp-content/uploads/2013/05/Costa\\_Concordia\\_-\\_Full\\_Investigation\\_Report.pdf](http://3kbo302xo3lg2i1rj8450xje.wpengine.netdna-cdn.com/wp-content/uploads/2013/05/Costa_Concordia_-_Full_Investigation_Report.pdf)

Lane, A. (2004, 19 April) Impact of Titanic Upon International Maritime Law. Retrieved from URL [https://www.encyclopedia-titanica.org/titanic-impact-on-maritime-law.html#\\_ftnref1](https://www.encyclopedia-titanica.org/titanic-impact-on-maritime-law.html#_ftnref1)

Laursen, W. (2015, 22 November). The Week in Review: Passenger Vessel Safety. Retrieved from URL <https://maritime-executive.com/editorials/the-week-in-review-passenger-vessel-safety>

LSA - Code. (1998). Retrieved from URL <http://treaties.fco.gov.uk/docs/pdf/1998/TS0044.pdf>

Marc Tiley. (2012, 31 January). Terror at Sea: The Sinking of the Concordia [Video file]. Retrieved from URL <https://www.youtube.com/watch?v=5SaaBLhW2p4>

MONALISA 2.0. (2015). Activity 3, Requirement Specification of the SES, ch. 7, technical specification. Retrieved from URL <http://s3-eu-west-1.amazonaws.com/stm-stmvalidation/uploads/20160420145610/ML2-D3.4.1-SES-Requirement-Definition.pdf>

MONALISA 2.0. (2015). Activity 3, Launching and Recovering System Design, ch. 4.2. Retrieved from URL <http://s3-eu-west-1.amazonaws.com/stm-stmvalidation/uploads/20160420145332/ML2-D3.4.2-SES-System-Design-Launching-and-Recovery.pdf>

MONALISA 2.0. (2015). Activity 3, Pilot Application. Retrieved from URL <http://s3-eu-west-1.amazonaws.com/stm-stmvalidation/uploads/20160420145317/ML2-D3.4.4-SES-Pilot-Application.pdf>

MONALISA 2.0. (2015). Activity 3, Safe Evacuation System: System Validation. Retrieved from URL <http://s3-eu-west-1.amazonaws.com/stm-stmvalidation/uploads/20160420145310/ML2-D3.4.5-SES-System-Validation.pdf>

Peacetime shipping disasters - Timeline. (2012, 15 January). The Guardian. Retrieved from URL <https://www.theguardian.com/world/2012/jan/15/peacetime-shipping-disasters-timeline>

Safety of Life at Sea, 1974 (SOLAS)

Smith, J. (2010). Miracle on the Wild Coast - Sinking of the Oceanos. [Video file]. Retrieved from URL <https://www.youtube.com/watch?v=E6Ifnl3Iung>

Saul, J & Berkowitz, B. Reuters. (2012, 20 January). Analysis: Italy disaster shows Titanic lifeboat issues linger. Retrieved from URL <https://www.reuters.com/article/us-italy-ship-lifeboats/analysis-italy-disaster-shows-titanic-lifeboat-issues-linger-idUSTRE80J1UR20120120>

Swedish Maritime Administration. (2012). Retrieved from URL <http://www.sjofartsverket.se/en/MonaLisa/MONALISA-20/>

Swedish Shipowners' Association. (2018). Swedish shipping in brief. Retrieved from URL <http://www.sweship.se/svensk-sjofart-i-korthet/>

The Joint Accident Investigation Commission consisting of: Ministry of Transport and Communications, Estonia. Accident Investigation Board, Finland Board of Accident Investigation, Sweden. (1997). Final report on the MV ESTONIA disaster of 28 September 1994. Retrieved from URL <http://onse.fi/estonia/> and [http://www.havkom.se/assets/default/Estonia\\_JAICrapport\\_Sv.pdf](http://www.havkom.se/assets/default/Estonia_JAICrapport_Sv.pdf)

The Royal Institution of Naval Architects. Retrieved from URL [https://www.rina.org.uk/costa\\_concordia\\_passenger\\_evacuation.html](https://www.rina.org.uk/costa_concordia_passenger_evacuation.html) and <https://www.rina.org.uk/mega-lifeboat.html>

The Swedish Transport Agency. 2018. About us. Retrieved from URL <https://transportstyrelsen.se/en/About-us/>

## **Appendix**

### **Appendix 1 – SOLAS 1914**

#### **Article XII**

##### **Davits.**

Each set of davits shall have a boat of the first class attached to it, provided that the number of boats of the first class attached to davits shall not be less than the minimum number of fixed by the Table which follows.

If it is neither practicable by the rules, the Government of the State to which the ship belongs may authorise a smaller number of sets of davits to be fitted, provided always that this number shall never be less than the minimum number of open boats of the first class required by the rules.

If a large proportion of the persons on board are accommodated in boats whose length is greater than 15 metres (equivalent to 50 feet) a further reduction in the number of sets of davits may be allowed exceptionally if the Administration concerned is satisfied In that the arrangements are in all respects satisfactory.

In all cases in which a reduction in the minimum number of sets of davits or other equivalent appliances required by the rules is allowed, the owner of the ship in question shall be required to prove, by a test made in the presence of a surveyor appointed by the Government, that all the boats can be efficiently launched in a minimum time.

The conditions of this test shall be as follows :--

1. The ship is to be upright and in smooth water:
2. The time is the time required from the beginning of the removal of the boat covers, or any other operation necessary to prepare the boats for lowering, until the last boat or pontoon raft is afloat:
3. The number of men employed in the whole operation must not exceed the total number of boat hands that will be carried on the vessel under normal service conditions;
4. Each boat when being lowered must have on board at least two men and its full equipment as required by the rules.

The time allowed for putting all the boats into the water shall be fixed by a formula to be determined by the Government of each High Contracting Party, each Government undertaking to communicate its decision to the Government of the other Contracting Parties.

**Article 49.**  
**Strength and operation of the davits.**

The davits shall be of such strength that the boats can be lowered with their full complement of persons and equipment, the ship being assumed to have a list of 15 degrees.

The davits must be fitted with a gear of sufficient power to ensure that the boat can be turned out against the maximum list under which the lowering of the boats is possible on the vessel in question.

## **Appendix 2 - Interviews**

### **Swedish Shipowners' Association**

The Swedish Shipowners' Association is a part of the Swedish delegation to IMO. Their mission is to promote issues globally and to increase the knowledge of the Swedish shipping industry. This interview was made at their office in Gothenburg, the interviewee is a previous master mariner and has been active for many years in different parts of the industry.

He had respect for the launching lifeboats with a substantial heel. He had no opinion whether or not today's rules of 20° is sufficient and this question is not to his knowledge being discussed in Sweden. However, after the sinking of Costa Concordia there has been a lot of discussions on how to prevent ships from reaching that kind of list.

Regarding IMO, Swedish Shipowners' Association has a lot of cooperation with them and he was convinced it has or is being discussed at some level. We feel like the shipping industry is a reactive one and wanted to know what he thinks is needed for a change. The reply was that within IMO there is a lot of politics, some countries can veto and with over 170 states that have to agree it takes time but once the rule is passed, it is mandatory for almost the whole world which makes it very impactful. However, there is a real willingness to improve safety and it does not necessarily have to be another accident but if someone comes up with a good solution within a certain price range of what the industry pays today they will most certainly adopt and deploy this solution themselves, years before it is mandatory.

### **Swedish shipping companies**

From the Swedish companies operating passenger vessels that were contacted regarding the issue of launching lifeboats during a heavy list we received two replies. Two from working maritime officers and the other a safety superintendent ashore but we were unable to obtain a lot of information nor opinions. The reply over email was that this is a very interesting question but for them to discuss it would only be to speculate. Luckily, they do not have any experience in launching lifeboats in conditions over 20° list. Their vessels and equipment are constructed and approved according to regulation and they presume it will work and cannot do more than to continue to conduct drills in "normal" condition.

### **Lecturer with a PHD in shipbuilding technology**

We had the opportunity to interview a lecturer in shipbuilding technology at Chalmers university of technology. He has been involved in calculation scenarios surrounding the sinking of m/s Estonia. It was his opinion that today the prevention of ships to reach a heel of 20° is more discussed though you should not “put all your eggs in the same basket” and looking into the launching system and the rules surrounding this is also vital.

As previously stated in this report, it is required for ships to be able to launch lifeboats with a heel up to 20°. One of the main questions for this interview was to find out how much shipbuilders calculate on the amount of time the ships are expected to have before reaching this critical angle. There are no rules making it mandatory to calculate and know this specific kind of information though he has some experience within the area.

Perhaps the most remarkable piece of information to come out of any of the interviews came when we asked him how many vessels that sink with a list over 20°. His answer was that close to all passenger vessels, especially those with car decks that will dramatically increase the free surfaces affect thus affecting the stability of the vessel even more, will at some point completely capsize before sinking. Even though the watertight compartments go all the way through a vessel, from port to starboard, the chance of a passenger vessel sinking without a list is close to nil. When all stability is lost some external force will push the vessel onto one of its sides.

Generally, today, lifeboats are placed lower on the ships. Launching lifeboats from a lower point when the vessel suffers from a list makes the sideways distance it has to travel shorter and thus making it easier to launch. This does however give the lifeboats on the lower side, leaning towards the water a shorter amount of time to launch before it reaches the water and it will be too late. It is the interviewee's opinion that this is, anyway, a better solution.

### **Swedish Transport Agency**

The Swedish Transport Agency is the supervisory authority responsible for making Swedish shipping safer. Some of their tasks being, issuing certificates, Swedish rules and regulations and documenting accidents and incidents. Moreover, the Swedish Transport Agency is part of the Swedish delegation to IMO and have a part in meetings.

The interview held was with the department responsible for life saving equipment's. The objective with this interview was to see how the Swedish Transport Agency works in relation to IMO with rules and regulations. But also, if they had any personal opinions regarding the launching of lifeboats when the ship is heeling over 20°, according to the LSA - code.

The interviewee said he had not heard any discussions within the marine expert group regarding the issue with launching lifeboats at a higher heel angle than 20°. The marine expert group



conduct tests on lifeboat launching. Furthermore, he had not heard any discussions within IMO on this matter, although he had no direct link with the IMO.

According to the interviewee it does not work to launch lifeboats with a higher heel than 20°. It brings too much stress on the equipment which is not designed to work during these conditions and too complicated for the people to evacuate. He mentioned two projects that are looking at the possibility for an entirely different evacuation process, not involving lifeboats. With this said it was his opinion that presenting a fully working evacuation alternative that is cost effective and not too complicated, it is easier to implement with shipping companies and IMO. To get a temporary adoption on a working system is easier. On the contrary to changing the rules and regulation which takes several years, and you have to get it on the MSC and IMO's agenda.

### **Classifications societies**

No interviews were conducted with classification societies due to lack of response. Only one telephone conversation was held, not to be considered as an interview, where it was stated that; the classification society in question was only following the current rules and regulations when carrying out their duties.

### **MONALISA**

MONALISA 2.0 is a very relevant project for this report. During the work with SES they had a company in Spain, that also manufacture davits, to do a lot of tests regarding the launch of lifeboats with different angles. We were able to get a hold of this company and receive answers via mail through a person in MONALISA.

Since MONALISA is a relatively large project with a major budget we wanted to find out what they used to motivate that this problem with ships only being able to launch lifeboats with a heel up to 20° was relevant enough to spend money and time to look further into. The reply was that they used pictures from Costa Concordia and later found others that showed the same result.

Their result was that they managed to come up with (as previously shown in **3.2.1 Activity 3, SES (Safe Evacuation System)**) various solutions that could be deployed without a major cost. This however, should be a decision from the owners considering health, safety and insurances cost reductions. They also mention that it is important to look at the evolution of stability of a vessel before sinking, the longer it can stay below 20° heel the higher the chance of a successful evacuation. It is their opinion that this is an issue that should be discussed within the industry and IMO since technology has developed more than the regulations. To the question if today's rules of 20° is enough they reply, "it is never enough if just one more life can be saved". They do have some experience in this matter during projects for NATO and Coast guard vessels that have higher LSA requirements than commercial vessels. There seems to be a positive attitude towards increasing rules regarding safety and especially after accidents such as Costa Concordia where a lot of media coverage was given the company's focuses even more on safety.

## **Manufacturers of davits**

For the duration of this project contacting manufacturers have not given any results. With both mailing and calling, resulting in us being passed around to the right person.

## **Appendix 3 - SES, Activity 3**

Considering all the requirements that launching appliances must satisfy, which have been already mentioned in previous points, and after a deep study of evacuation methods and the main existing problems during such operations (on passenger vessels), it have been defined all the specific technical features that the system SES must meet:

- Reducing the friction between the hull of the lifeboat and the passenger vessel side during the evacuation, in order to maintain the angle between the hook and the davit throw at small values. This critical factor is usually guilty of prevent the release systems to work with heel angles above 20°. (please see notes in below drawings)
- The system must guarantee that the lifeboats can be positioned along the shipside in order to launch them to the sea.
- According to commercial issues, the system should be compatible, with small adaptations, with commercial launch appliances for lifeboats, and should be installed at different sort of vessels.
- The system must be capable to operate at heel conditions, either way but mostly to opposite side, much higher than conventional ones ( $> 20^\circ$ ).
- The system should be compatible with both telescopic and tilting launching devices.
  
- The system should be able to work also with empty lifeboats. At this point of the explanation, in which are already known all the requirements that the SES system satisfies, two equally valid solutions are proposed:
  1. One to prevent the boat to be lowered over the deck, and so guide it to the hull/vessel side. This with two options: one based on straps, and the other based on telescopic arms.
  2. Other with the technical proposal for minimizing the friction between the hull of the lifeboat and the ship- side of the passenger vessel, the slide system
  
- 1. a) A system based on straps
  - This system essentially consists of 2 or 3 straps that tighten at the time that the davit tilts/or its boom makes a telescopic movement (it depends on the sort of davit), in order to put out the lifeboat to prevent it from falling on the deck of passenger vessel but directly on the shipside.
  - Those 2-3 straps (it depends on the lifeboat) must have their ends anchored to the edge of the deck before starting the launch operations. On the deck of the vessels they will be already placed special clamped devices for an easy clamped operation when an evacuation is needed.

- The maximum tension that the straps will, support will be equal to the weight of the boat by the sine of  $30^\circ$  and divide by the number of straps (depending on the boat).
- Must be noted that the hull of the lifeboat will rely on the ship's hull with a force 45% higher than what the law requires, due to the increased angle of heel that the SES will work.

1. b) A system based on telescopic booms

- This system essentially consists of 2 telescopic arms that make a telescopic movement in order to put out the lifeboat to prevent it from falling on the deck of passenger vessel but directly on the shipside.
- The maximum tension that the booms will, support will be equal to the weight of the boat by the sine of  $30^\circ$  and divide by the number of straps (depending on the boat).
- Must be noted that the hull of the lifeboat will rely on the ship's hull with a force 45% higher than what the law requires, due to the increased angle of heel that the SES will work.

2.- Once the lifeboat is down the deck level and against the shipside, it starts to slide down. To facilitate this part of the launch operations, sliding pads will be fitted on the hull of the lifeboats in order to minimize the friction between those surfaces. With the lower friction, we get to minimize, the angle formed by the hook and davit throw, down to design values. Sliding pads are also designed to distribute the effort on the hull of the lifeboat (as we said, 45% over the design ones). These sliding pads will be placed no damaging the lifeboat's hull surface and adapting to the specific hull forms/shapes for each type of lifeboat. They will be also placed with minimum affect the hydrodynamics of the lifeboat in navigation.