# Use of behavioral theories for the interpretation of human behavior in the Costa Concordia disaster

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Abstract:
The Costa Concordia disaster represents one of the most dramatic ship evacuations of recent years. This thesis constitutes a case study of the Costa Concordia disaster, in an attempt to identify behaviors among the evacuees that may have contributed in reducing the effectiveness of the evacuation procedures. Publicly available material – such as reports from the media, survivor accounts and scientific investigations – was critically analyzed, and current behavioral models were used to interpret the behaviors identified.

*The author is responsible for the contents of the report*



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## Summary

Large-scale cruise ships and passenger ships have lately increased significantly in numbers and popularity. As a result the number of maritime accidents with passenger ships involved has also increased. The Costa Concordia disaster represents one of the most dramatic ship evacuations of recent years. International maritime law requires all passengers to be evacuated within 30 minutes of an order to abandon the ship, but the Costa Concordia evacuation lasted for more than six hours. Of the 3229 passengers and 1023 crew known to have been on board – 32 people drowned. As the cruise- and passenger ships keep getting bigger, with higher passenger capacities, the importance of well-functioning evacuation procedures also increases.

The purpose of this thesis was to perform a critical analysis of the publicly available data on human behavior during the Costa Concordia disaster as reported by the media, survivor accounts, and scientific investigations etc. The aim was to find possible behavioral factors that may have contributed in reducing the effectiveness of the evacuation, as well as identifying potential issues in the current evacuation procedures in ships – in light of the issues occurring during the disaster.

In order to get familiarized with the current regulations in the passenger ship industry, and common complications in the evacuation procedures in passenger ships, a literature study was carried out. The publicly available behavior-data was thereafter evaluated in light of current evacuation behavioral theories. One conclusion from this thesis is that the behavioral models proved to be useful in the interpretation of a passenger ship evacuation disaster, and it is suggested that they may also be valuable at a design stage when trying to predict behaviors and actions of people in a maritime disaster.

Furthermore, a number of behaviors were identified that might have contributed in reducing the effectiveness of the evacuation procedures, including;

- Confusion
- Freezing (cognitive paralysis)
- Competitive behavior
- Insecurity and hesitation

Several management and operational issues were also identified that may have contributed in reducing the effectiveness of the evacuation procedures.

- 696 passengers had not yet been briefed on the ship's safety procedures (as this was scheduled for the following day, 14$^{th}$ of January).
- The public and most of the staff were kept unaware of the severity of the situation, prohibiting them from getting mentally prepared for the evacuation.
- The delay of the assembling and disembarking procedures caused precious time to be lost and led to a narrow time frame for effective launching of lifeboats and rafts.

- Lack of communication between passengers and staff, as well as in between staff, involved language barriers and conflicting orders and led to confusion, misunderstandings and frustration among the passengers.
- Seeming lack of understanding and adequate training among part of the staff caused disbelief in the leadership among passengers.

To improve the safety in passenger ships it is proposed that additional measures, beyond what is currently stated in the regulations, are taken in order to ensure that;

- Passengers are given adequate information prior to and during an emergency.
- Staff is familiar with the emergency equipment and procedures.
- Staff is able to communicate with each other as well as with passengers.

## Sammanfattning

Stora kryssningsskepp och passagerarfärjor har ökat både i antal och popularitet på senare år, och följaktligen har antalet olyckor med passagerarbåtar också ökat. Costa Concordia-katastrofen utgör ett exempel på en av vår tids mest dramatiska evakueringar av passagerarfartyg. Utrymningen pågick i mer än sex timmar, trots att internationella sjöfartsregler tydliggör att alla passagerare ska vara evakuerade inom 30 minuter efter att order getts om att överge fartyget. Utav de 3229 passagerare och 1023 i besättningen som veterligen befann sig ombord vid tillfället omkom 32 människor. I takt med att kryssningsfartyg och övriga passagerarbåtar fortsätter att tillta i antal och storlek, så ökar även vikten av välfungerande utrymningsrutiner.

Syftet med detta examensarbete har varit att kritiskt granska och analysera det allmänna material som finns att tillgå gällande mänskligt beteende under Costa Concordia-katastrofen – genom att studera såväl medias tolkningar, som vittnesuppgifter från överlevande och vetenskapliga utredningar etc. Målet har varit att försöka hitta beteendemönster som kan ha påverkat utrymningens effektivitet negativt, samt att identifiera potentiella svagheter i de nuvarande utrymningsrutinerna på passagerarfartyg.

För att bli insatt i de nuvarande regelverken inom fartygsindustrin, och de vanligaste komplikationerna vid utrymning av passagerarbåtar, gjordes först en litteraturstudie. Därefter utvärderades de allmäntillgängliga uppgifterna om mänskligt beteende under Costa Concordia-katastrofen, med rådande teorier och modeller för mänskligt beteende vid utrymning i åtanke. En slutsats som dragits under arbetets gång är att modellerna är väl användbara för tolkningen av fartygsrelaterade evakueringskatastrofer. Det är också troligt att de kan bidra med värdefull information under ett planeringsstadium, för att förutspå människors beteende och handlingar vid olyckor ombord.

Vidare uppdagades ett antal beteendemönster som kan ha bidragit till att reducera utrymningens effektivitet;

- Förvirring
- Frysning
- Konkurrensbeteende (knuffar, trängsel etc.)
- Osäkerhet och tvivel

Flertalet organisatoriska fel och lednings-fel identifierades också som kan ha bidragit till att minska utrymningsprocedurernas effektivitet;

- 696 passagerare hade vid grundstötningen ännu inte blivit instruerade om säkerhetsrutinerna, eftersom detta var schemalagt till dagen därpå.
- Allmänheten, och merparten av besättningen, hölls ej informerade om situationens allvar, vilket hindrade dem från att förbereda sig mentalt på att evakuera.
- Förseningen av uppsamlings- och evakueringsprocedurerna ledde till att dyrbar tid gick förlorad, vilket i sin tur gjorde att tidsramen för att sjösätta livbåtarna avsmalnade kraftigt.

- Bristande kommunikation mellan passagerare och besättning, samt besättningsmän emellan, berodde på såväl språkbarriärer som på motsägelsefulla order – vilket ledde till förvirring, frustration och missförstånd bland passagerarna.
- Synbar avsaknad av utbildning och förståelse för utrymningsrutinerna orsakade misstro till ledarskapet hos passagerarna.

För att förbättra säkerheten ombord på kryssningsfartyg och övriga passagerarbåtar föreslås att en ansträngning görs (utöver rådande regelverk) för att säkerställa att;

- Passagerare ges tillräcklig information, dels innan en olycka inträffat, samt när den väl inträffar.
- Personalen är väl insatt i säkerhetsrutiner och vet hur säkerhetsutrustning används, samt känner sig trygga i att använda den.
- Personalen kan kommunicera med varandra såväl som med passagerarna.

## Acknowledgements

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## Glossary of abbreviations and acronyms

**AIS** – Automatic Tracking System
**Carabinieri** – Italian National Military Police
**FCC** – Fleet Crisis Coordinator
**IB** – Investigative Body
**LSA** – Life-Saving Appliance
**IMO** – International Maritime Organization
**ISM Code** – International Management Code for the Safe Operation of Ships and for Pollution Prevention
**Martec system** – Software that manages the controls for emergency breach and fire
**MRCC** – Maritime Rescue Coordination Centre
**MRSC** – Maritime Rescue Sub Center
**MSC** – Maritime Safety Committee
**OSC** – On Scene Commander
**RO-PAX** – High-speed roll-on/roll-off ferry
**RO-RO** – Roll-on/roll-off ferry
**SAR** – Maritime Search and Rescue
**SOLAS** – International Convention for the Safety of Life at Sea
**SMS** – Safety Management System
**STCW** – International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
**UCG** – Coastal Guard Unit
**WTC** – Watertight compartment

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# 1 Introduction

This chapter presents the background, aim and objectives, research questions, methodology, and delimitations of the thesis.

## 1.1 Background

Large-scale cruise ships and passenger ships have increased largely in popularity and numbers over the years, as a result so have also the number of maritime accidents with passenger ships involved. Several of the accidents have had fatal outcomes, just to mention a few; the Herald of Free Enterprise sank in March 1987, shortly after leaving the port of Zeebrugge in Belgium. The accident occurred because the bow door was left open as the ship left port – allowing water to enter and flood the car deck, resulting in the deaths of 193 passengers and crewmembers. In 1990 the Danish ship MS Scandinavian Star caught fire during a trip from Norway to Denmark, resulting in the loss of 165 lives. In 1992 a Royal Pacific cruise ship collided with a fishing trawler, resulting in 30 deaths and 70 injured. In September 1994 the RO-RO passenger ship MS Estonia capsized in a severe storm in the Baltic Sea and sank with the loss of 852 lives. In 2005 the Norwegian Dawn cruise ship was hit by a 20-meter wave that flooded 62 of the cabins. In December 2014 the passenger ship Norman Atlantic caught fire on its route between Greece to Italy, 427 people were saved but 10 persons lost their lives.

The Costa Concordia disaster represents one of the most dramatic ship evacuations of recent years. On 13 January 2012, the cruise ship struck a rock just off the eastern shore of Isola del Giglio, on the Italian west coast. The impact tore a 53 meter gash to the port side of the hull, which flooded parts of the engine room and caused power loss and damage to the ship's electrical systems. Despite the fact that the ship was gradually sinking, an order to evacuate was not carried out until over an hour after the initial impact. International maritime law requires all passengers to be evacuated within 30 minutes of an order to abandon the ship, but the Costa Concordia evacuation took over six hours. Of the 3229 passengers and 1023 crew known to have been on board, 32 people drowned.

As the cruise and passenger ships keep getting bigger, with higher passenger capacities, the importance of well-functioning evacuation procedures also increases.

## 1.2 Aim and objectives

The purpose of this thesis is to analyze the data available from media on human behavior during the Costa Concordia disaster. The scope is to make a critical analysis of the information collected, and to perform an evaluation of the factors leading to issues in the evacuation procedures in light of current evacuation behavioral theories. This analysis will be used to identify the key issues occurring as well as potential improvements for evacuation procedures in ships. The aim of the thesis is:

- To collect publicly available information on human behavior in the Costa Concordia disaster such as public information from the media, available accounts from survivors, public scientific studies and investigations.

- To categorize the behaviors of the passengers in light of evacuation behavioral theories.
- To find possible behavioral factors which may have contributed in reducing the effectiveness of the evacuation procedures.
- To identify potential issues in current evacuation procedures in ships as discussed in the IMO (international Maritime Organization) regulations in light of the issues occurring during the disaster.

## 1.3 Research questions

- How could the evacuation be more effective?
- How can behavioral theories be used to interpret a ship evacuation disaster?
- 'Lessons learned' – What commonly identified issues in the disaster can be used to improve safety in passenger ships (from both a regulatory and enforcement perspective).

## 1.4 Methodology

The method consists of a critical review of the publicly available information, such as the information from the media, available accounts from survivors, public scientific studies and investigations, etc.

The next step is to present the current regulations and procedures in the passenger ship industry (as per the IMO, SOLAS documents etc.) and to give an introduction of some common complications in the evacuation procedures of large-scale passenger ships.

Thereafter a study of different behavioral evacuation theories, such as social influence, affiliation, role rule, behavior sequence etc. will be carried out.

In light of the various human evacuation behavioral theories, the information received from the previous research will be analyzed to address the research questions.

## 1.5 Delimitations

This thesis will focus on the human behavior aspects of the evacuation process only. No investigation of judgmental calls from the Captain or crewmembers prior to the accident will be carried out.

# 2 Theoretical: human evacuation behavior

Over the past decades, there has been much research on human behavior in evacuation situations and a variety of theories and models have been developed to explain the reactions and behavior of evacuees. Most commonly the studies have been focusing on evacuation from building fires, however the same models and theories may be applied to describe the evacuation of a passenger ship.
A cruise ship can merely be seen as a rather big floating building. Within this chapter, some of the models and theories for understanding human evacuation behavior are presented. A direct link to evacuation of passenger ships may not be clear, as these theories and models constitute the foundation for understanding human behavior in fire and evacuation in general.

## 2.1 The behavior sequence model

People do not necessarily evacuate at the first signs of a fire or emergency. In fact, time may be spent to interpret the first signs of the emergency, which then forms the basis of the decision making on how to act under the specific circumstances.

By studying numerous cases of domestic, multiple occupancy, and hospital fires, Canter et al. (1980) developed the behavior sequence model to explain this process. After interviewing a total of 198 fire victims from 28 different fires, they found that there were characteristic patterns of behavior that occurred in all types of occupancies. With this in mind, Canter et al. (1980) proposed a general behavior sequence model (see Figure 1). The model can be described by the following three sequence categories, or so-called nodal points:

1. Interpret
2. Prepare
3. Act

Each nodal point forms a behavior sequence, e.g., a sequence of consecutive actions that people may perform. As the sequence of behavior unfolds, the number of potential actions increases. This means that statements about initial actions and behaviors are likely to be made with a higher degree of certainty than about actions later in the sequence. Canter et al. (1980) also concluded that actions in the lower part of Figure 1 are more likely to depend on the type of occupancy.

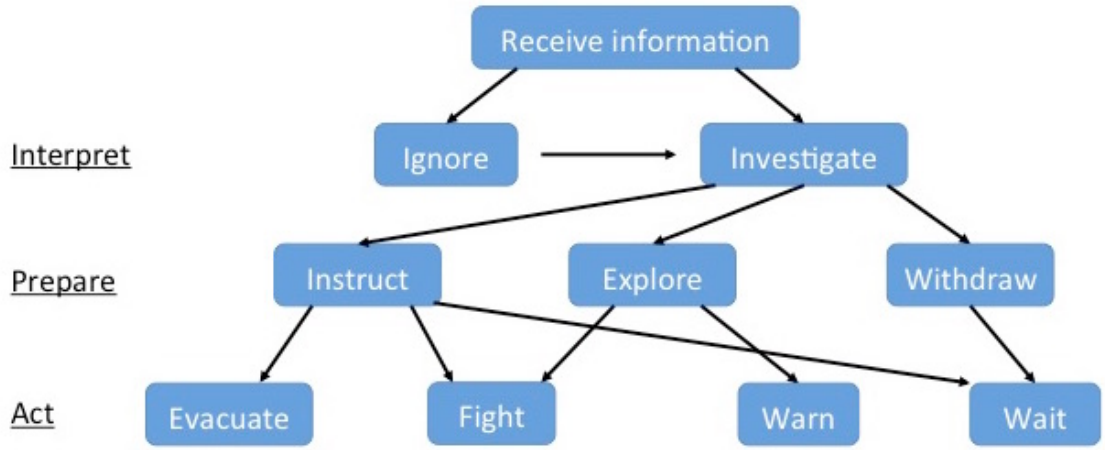


**Figure 1 The behavior sequence model is a general model that can be used to describe the sequence of consecutive actions that people perform in a fire, or other emergency situation.**

It is to be noted that the behavior sequence model is merely a general model, and that it only summarizes the most frequent behaviors identified by Canter et al. (1980). It does not explain the specific behavior of each individual, and behavior sequences do not necessarily follow the arrows of Figure 1. Still, the model presents a valuable summary of the sequence categories that an individual may typically experience.

The behavior sequence model can be used to describe why people in a passenger ship emergency do not necessarily start to evacuate at the first sign of danger. Typically, information is scarce and ambiguous at the initial stages of an emergency. An indication could, for example, be the smell of smoke. Such a vague signal is not very likely to immediately initiate an evacuation of a ship. It is more likely it will be ignored, or at best initiating an investigating behavior that can reduce the uncertainties about the situation.

The initial decision making that a person does, at the early stages of an emergency situation, is most often associated with doubts and uncertainties (Canter et al., 1980). As more information is received, the uncertainties associated with the decision-making are reduced. It is therefore more likely that a person will be able to correctly interpret, prepare, and act appropriately as more information is provided – especially if the information is comprehensible (Kuligowski, 2013). On the other hand, Kuligowski (2013) also points out that people may neglect taking protective action if the information is misinterpreted, or if provided with faulty information.

## 2.2 The affiliative model

Another model that can help the understanding of human behavior in fire, as well as other emergency situations, is the affiliative model developed by Sime (1983, 1985). It was developed as a response to the so-called physical science model, as described by Phillips (1951) and Peschl (1971) amongst others. The physical science model equates people with "non-thinking objects" and assumes that people are most inclined to evacuate via the shortest exit route available (Sime J. , 1985). The affiliative model however suggests that people are more likely to move towards familiar places and/or people when they are in a threatening situation. In example, this means that in an emergency situation, people are more likely to use the same exit as they would use under normal circumstances or exit via the same route they entered a building. Subsequently, this also explains why people tend to avoid using special emergency exits, as these are generally not used under normal circumstances (Sime J. , 1985).

The affiliative model also suggests that people are more likely to evacuate in groups where the individuals have previous bonds to each other, such as family members, friends, or colleagues. The fact that people in emergency situations tend to move to familiar persons has also showed to have an impact on the interpretation of ambiguous cues, and consequently, on the time it takes to evacuate. For example, Sime (1983) noticed that people that were separated from their family members seemed to respond very quickly to initial indications of fire. In contrast, people that are surrounded by their group when receiving the initial cues have shown to delay their decision to evacuate until there have been clear signs of a fire threat. A possible explanation for these two distinct outcomes may be that the initial indications of a fire (or other emergency) prompt individuals who are separated

from their group to go find them, even if the indications are vague. Individuals of complete groups may on the other hand gain a deceptive feeling of security for being part of their group.

As passenger ships are unfamiliar environments to the majority of the people aboard, the affiliation model can be used to explain peoples' hesitancy to evacuate. Obviously, unfamiliarity is not the only reason, and the behavior sequence model may provide additional reasons for this hesitancy. The affiliative model can also be used to explain why people aboard a passenger ship may form groups during an evacuation.

## 2.3 Social influence

As discussed in the previous sections, the presence of other people has shown to have an impact on an individual's decision to evacuate. As an example of this phenomenon, it has been noticed that individuals that are alone respond much quicker to indications of fire compared to individuals that are part of a group (Latané & Darley, 1968). Nilsson and Johansson (2009) observed similar behavior patterns when carrying out unannounced evacuation experiments at a cinema theater. Their studies suggest that social influence is a factor of great importance when it comes to initial decision-making, and that it becomes even more important when the initial cue, e.g., the alarm, is unclear or uninformative. Similar observations have also been made by Kinateder (2013), Kinateder et al. (2014a), Kinateder et al. (2014b), and Lovreglio et al. (2015). Nilsson and Johansson (2009) further concluded that individuals seem to be more influenced by people who are close, compared to people farther away.

Social influence can be divided into two sub-categories – normative social influence and informational social influence (Deutsch & Gerard, 1955). Normative social influence is defined as an influence to "conform to the positive expectations of another" (Deutsch & Gerard, 1955). In this context, positive expectations refer to expectations that lead to a positive feeling when fulfilled by another, e.g., the prevalent norms. People in general are afraid to deviate from the norms and therefore often adapt their individual judgments to the believed expectations of others. Informational social influence on the other hand is defined as an "influence to accept information obtained from others as evidence about reality" (Deutsch & Gerard, 1955). In other words, this means that individuals look to other people for information in ambiguous situations, and when unsure of how to behave.
In many emergency situations the information is scarce, especially during the initial stages, as of why social influence is very likely to affect the sequence of individual behaviors that unfolds.

In the case of a passenger ship disaster, the effect of social influence can be both positive and negative. The normative aspect can constrain peoples' response, and thereby delay the evacuation. As previously suggested, the affiliative model might explain peoples' hesitancy to evacuate. This hesitancy is most likely intensified by the fact that using emergency exits and embarking into the lifeboats is not considered as the norm. On the other hand, informational social influence can have a positive effect if people see others evacuate or head for the muster stations. This is a strong signal that they themselves should also react, and it can evidently reduce

the initial uncertainties associated with the decision making, as illustrated in the behavior sequence model in Figure 1.

## 2.4 The role-rule model

Canter et al. (1980) demonstrated that behavior sequences, e.g., how a specific person responds to a fire, are greatly depending on the role of the person. When reviewing the general behavior sequence model, they found consistencies among the behavior of people from similar groups. For example, they discovered that in the case of hotel fires, staff behaved differently from the guests. The same tendencies were identified in hospital fires, where staff continued their duties to patients, and in residences, where parents ensured the safety of their children. It is clear that the behavior of people depend on the circumstantial role in which they see themselves (Pigott, 1989).

Eventually the role-rule model was formed, suggesting that; "people's conduct is guided by a set of expectations they have about their purpose in a particular context" (Tong & Canter, 1985). These expectations set a general framework, which forms a person's role. Each role is linked to a set of rules, which can be seen as guiding principles associated with the role that a person has adopted. Canter et al. (1980) argue that when a person is faced with a fire threat, his or her behavior continues to be guided by the role-rule influences, which had been operating prior to the emergency.

In a fire, or other emergency situations aboard a passenger ship, contextual roles and associated rules can be expected to have an impact on the sequence of consecutive actions that people perform. Consequently, the authoritative personnel can be expected to interpret, prepare and act differently on cues of fire etc. compared to the passengers.

## 2.5 The definition of 'panic' and its misconceptions

The media, as well as surviving victims of disasters such as fires, shipwrecks, earthquakes, floodings etc., frequently use the term 'panic' to describe the events of a disaster. Despite plentiful evidence of panic being an exceptionally rare occurrence, the idea of panic and the term itself continue to be exaggeratedly used by the public as well as by experts (Fahy, Proulx, & Aiman, 2009). Furthermore, Roytman (1975) wrote that panic has often been thought of as something that could "spread among evacuees like a highly infectious decease", and crowd behavior in disasters has often been referred to as 'mass panic' (Drury, Cocking, & Reicher, 2009a).

To clarify the term 'panic', Fahy et al. (2009) made a thorough study on its various definitions, as well as a case study to examine the concept from the view of the general public and media. Goldenson (1984) defined panic as "a reaction involving terror, confusion and irrational behavior, precipitated by a threatening situation". He further described panic as "a collective flight based on a hysterical belief, a belief that a definite threat is present and that escape routes are closing". Based on Goldenson's definition, Johnson (1987) suggested that it's better to use the term 'unregulated competition' as a descriptive label when relating to the behavior of disaster evacuees. His argument was that although the behavior can become highly selfish and aggressive, it is not as a result of irrational panic, but rather of the

emergent definitions of the situation in which norms of civility no longer apply, and to compete for individual advantage is therefore legitimate and also quite rational. Keating (1982) outlined four elements of panic, namely: a) hope to escape through dwindling resources; b) contagious behavior; c) aggressive concern about one's own safety; and d) irrational, illogical responses. Quarantelli (1954) describe panic as an acute reaction of fear, distinguished by flight behavior, and the panicking person as irrational in his or her flight behavior. However, flight behavior in general is not to be confused with panic, as flight behavior itself can be rational in a disaster situation. This was also pointed out by Wenger (1978), who suggested that it is rather non-adaptive flight as a form of mass behavior that should be considered as panic. His conditions for panic also include; a) when danger is perceived as a specific threat and this results in a social crisis, b) only one or limited escape routes exist, c) people believe that escape is possible, d) people believe that competition rather than cooperation is necessary for escape, and e) there is a lack of ties to other individuals.

Fahy et al. (2009) found that in most of the literature on human behavior, panic is defined as some sort of irrational behavior. They also noted that human behavior under stressed situations, such as disasters, is usually relatively controlled, rational and adaptive. Furthermore they found that cooperation is predominant to selfish behavior, even among total strangers. However, panic is often reported when people observe the behavior of others, if it leads to an unsuccessful outcome. The term is also widely misused when people describe their own state of intensified anxiety or fear, although the actions they report taking themselves are typically both rational and appropriate (Fahy, Proulx, & Aiman, 2009). Similar findings have also been done by (Cocking & Drury, 2014).

Critique towards the concept of 'mass panic' has grown from the observations that crowd behavior in emergencies is typically characterized by sociality and solidarity rather than by individualized competition (Drury, Cocking, & Reicher, 2009a). In an attempt to explain some of the aspects of crowd behavior in emergencies, Drury et al. (2009a) followed the self-categorization theory as they interviewed 21 survivors from 11 disasters involving crowd evacuation. The theory can be used to determine a person's level of group-identification (Turner et al., 1987). The aim of the study was to compare high- versus low- identification survivors. The results of the study suggest that "shared identity in an emergency crowd enhances expressions of solidarity and reduces 'panic' behavior and that such a shared identity can arise from the shared experience of the emergency itself" (Drury, Cocking, & Reicher, 2009a). They study also showed that high-identification survivors saw, received, and gave more aid to others, compared to those of low group identification. Drury et al (2009a) further concluded that panic is rather a feature of individuals, not of crowds, and that the mass sociality observed in emergencies is a consequence of shared self-categorization rather than a function of pre-existing social bonds.
The findings of this study are further strengthened by the studies of Drury et al., (2009b), which also suggests that competitive behavior, such as pushing, is more likely to be adopted by people of low group identification. In addition, it was also noticed that pushing increased as the size of the crowd increased. However, people may push more in larger crowds simply because of physical constraints, rather than personal selfishness (Chertkoff & Kushigian, 1999; Cornwell, Harmon, Mason, Merz, & Lampe, 2001).

Sime (1990) pointed out that one major problem with using the term panic is that "panic behavior is often attributed to a person by an 'observer,' while the person supposedly engaged in the panic behavior has a very different perspective on what occurred". Furthermore, Brennan (1999) discovered several cases with substantial discrepancies in reported behavior between people that were present at the same event – in these cases, each person had a rational explanation for his or her own behavior, while that same behavior had appeared irrational or panicky to others.

As previously suggested, panic is also frequently referred to in the media's covering of various disasters. There are for example many cases in the reporting of mass-casualty events, where the media has proclaimed that the cause of the deaths was panic (Fahy, Proulx, & Aiman, 2009). Fahy et al. (2009) concluded that; "panic will remain a concern of the public as long as the term continues to be used frequently in media accounts, reinforcing the impression that it is a common and possibly inevitable occurrence". They therefore suggest that the media needs to take a greater responsibility in making accurate reports of peoples' behavior; this also applies to many human behavior scientists.

# 3 Regulations and procedures

Passenger ships and RO-RO ferries today are subject to a vast array of regulations and standards. The aim of this chapter is to give a brief introduction to some of the current regulations and procedures in the passenger ship industry.

## 3.1 IMO

The International Maritime Organization (IMO) is a specialized agency of the United Nations, established to act as a global standard-setting authority for the safety, security and environmental performance of international shipping. "Its main role is to create a regulatory framework for the shipping industry that is fair and effective, universally adopted and universally implemented" (IMO, 2014a).

When the IMO convention was gathered for the first time in 1959, one of its first tasks was to update the International Convention for the Safety of Life at Sea (SOLAS), which is widely regarded as the most important of all treaties concerning maritime safety (IMO, 2014b). The earliest version of SOLAS was adopted in 1914 as a response to the Titanic disaster and has been updated continuously ever since. The 1974 version of SOLAS includes a tacit acceptance procedure – which is why the Convention in force today is often referred to as SOLAS, 1974, as amended (IMO, 2014b).

In response to a series of incidents at sea between the late 80's and the beginning of the 90's, the IMO adopted a series of amendments to the SOLAS, including those relating to fire safety measures (such as escape routes and fire protection systems), life-saving appliances and arrangements, stability regulations, as well as operational requirements such as that for an established working language (IMO, 2014c). Besides making improvements to the technical regulations of the SOLAS Convention, the IMO also introduced the ISM Code for passenger ships, which has been an important step in focusing on the "human element" side of shipping, as well as the STCW Convention, which sets the standards of competence for seafarers internationally (IMO, 2014c).

Apart from the aforementioned codes and regulations, the IMO has also established international collision regulations and international conventions and codes relating to search and rescue etc. (IMO, 2014b). Recently the IMO has also recognized the need to focus on the ferries that do not come under SOLAS. They are therefore currently working on the development of standards for "non-convention" vessels (e.g. the passenger ferries that for reasons of being operated inland or solely on domestic routes are not required to conform with SOLAS) (IMO, 2014d).

## 3.2 SOLAS

The main purpose of the SOLAS Convention is to "specify minimum standards for the construction, equipment and operation of ships, compatible with their safety" (IMO, 2014b). Within the documents it is also specified how, and by whom, inspections are to be carried out to ensure that all ships comply with the regulations and requirements, as applicable. The SOLAS Convention includes a set of Articles that specify the general obligations, the terms for the amendment procedure and so on, followed by an Annex of 12 Chapters.

It is not within the scope of this thesis to analyze and recapture the entire content of the SOLAS Convention. However, a few extracts from some of the regulations that apply to passenger ships and RO-RO ferries are presented briefly below to make some examples (note that the regulations below are as of 2014, hence why Ch. III, regulation 19.2.2 is not up to date).

Chapter II-2 gives detailed specifications for the fire safety provisions, including; construction of firecells, fire detection, containment of fire and fire extinction, notification of crew and passengers, means of egress, etc. For example;

Chapter II-2, Regulation 12 – *Notification of crew and passengers*

1. The purpose of this regulation is to notify crew and passengers of a fire for safe evacuation. For this purpose, a general emergency alarm system and a public address system shall be provided.
2. A general emergency alarm system required by regulation III/6.4.2 shall be used for notifying crew and passengers of a fire.
3. A public address system or other effective means of communication complying with the requirements of regulation III/6.5 shall be available throughout the accommodation and service spaces and control stations and open decks.

Chapter II-2, Regulation 13 – *Means of escape*

1. The purpose of this regulation is to provide means of escape so that persons on board can safely and swiftly escape to the lifeboat and liferaft embarkation deck. For this purpose, the following functional requirements shall be met:
   1.1. safe escape routes shall be provided;
   1.2. escape routes shall be maintained in a safe condition, clear of obstacles; and
   1.3. additional aids for escape shall be provided as necessary to ensure accessibility, clear marking, and adequate design for emergency situations.
2. General requirements
   2.1. Unless expressly provided otherwise in this regulation, at least two widely separated and ready means of escape shall be provided from all spaces or groups of spaces.
   2.2. Lifts shall not be considered as forming one of the means of escape as required by this regulation.

Chapter III deals with the requirements for life-saving appliances and arrangements such as; lifeboats, rescue boats, lifejackets, muster list and emergency instructions, manning and supervision of survival crafts, emergency drills, abandon ship drill, etc. For example;

Chapter III, Regulation 10 – *Manning of survival craft and supervision*

1. This regulation applies to all ships.
2. There shall be a sufficient number of trained persons on board for mustering and assisting untrained persons.
3. There shall be a sufficient number of crew members, who may be deck officers or certificated persons, on board for operating the survival craft and launching arrangements required for abandonment by the total number of persons on board.
4. A deck officer or certificated person shall be placed in charge of each survival craft to be used. However, the Administration, having due regard to the nature

of the voyage, the number of persons on board and the characteristics of the ship, may permit persons practiced in the handling and operation of liferafts to be placed in charge of liferafts in lieu of persons qualified as above. A second-in-command shall also be nominated in the case of lifeboats.
5. The person in charge of the survival craft shall have a list of the survival craft crew and shall see that the crew under his command are acquainted with their duties. In lifeboats the second-in-command shall also have a list of the lifeboat crew.
6. Every motorized survival craft shall have a person assigned who is capable of operating the engine and carrying out minor adjustments.
7. The master shall ensure the equitable distribution of persons referred to in paragraphs 2, 3 and 4 among the ship's survival craft.

Chapter III, Regulation 19 – *Emergency training and drills*
1. This regulation applies to all ships.
2. Familiarity with safety installations and practice musters
   2.1. Every crew member with assigned emergency duties shall be familiar with these duties before the voyage begins.
   2.2. On a ship engaged on a voyage where passengers are scheduled to be on board for more than 24 h, musters of the passengers shall take place within 24 h after their embarkation. Passengers shall be instructed in the use of the lifejackets and the action to take in an emergency.

Regulation XI-2/8 of Chapter XI confirms the Master's role of exercising his professional judgments over decisions necessary to maintain the security of the ship. It says he shall not be constrained by the Company, the charterer or any other person in this matter.

(IMO, 1974)

## 3.3 LSA code

The Maritime Safety Committee adopted the International Life-Saving Appliances (LSA) Code in 1996. It provides additional information of the international requirements for the life-saving appliances that are required by chapter III of the SOLAS Convention, including: personal life-saving appliances, visual aids, survival crafts, rescue boats, launching and embarkation appliances, general alarm and public address systems, etc. (Witherby Seamanship International, 2010).

## 3.4 ISM Code

Management faults were sometimes identified amongst the contributing factors to some of the serious passenger ship accidents that occurred during the late 1980's. In 1989 the IMO adopted Guidelines on Management for the Safe Operation of Ships and for Pollution Prevention, which purpose was to provide the seafarers with a "framework for the proper development, implementation and assessment of safety and pollution prevention management in accordance with good practice" (IMO, 2014d). After four years of experience in using these guidelines, the International Management Code for the Safe Operation of Ships and for Pollution Prevention (the ISM Code) was adopted, and in 1994 the IMO made amendments to the SOLAS to make the ISM Code mandatory.

The ISM Code determines the safety-management objectives and it is required that the Company (e.g. the ship owner, or any person who has assumed responsibility for operating a ship) establishes a safety management system (SMS). Furthermore the Company is required to establish and implement a policy for reaching these objectives, which includes the provision of necessary resources and shore-based support. "Every company is expected 'to designate a person or persons ashore having direct access to the highest level of management'" (IMO, 2014d). The ISM Code also requires obligatory procedures to be documented and assembled in a Safety Management Manual, of which a copy must always be kept onboard.

## 3.5 STCW Convention

The International Convention on Standards of Training, Certification and Watch keeping for Seafarers sets the standards of competence for seafarers internationally. It includes the specific training requirements for all crewmembers on passenger ships and RO-RO ferries. In example, it specifies how the crew should be trained in crowd management, for use in emergency evacuation situations etc. The STCW Convention also empowers the IMO to check for Parties' compliance with the Convention. This is important as there are reportedly many unqualified seafarers holding fraudulent certificates within the shipping industry, being a danger not only to themselves but also to others onboard and to the marine environment (IMO, 2014e).

## 3.6 Response to the Costa Concordia incident

A few months after the Costa Concordia incident, the IMO's Maritime Safety Committee (MSC) agreed on temporary recommendations in operational measures for passenger ships. In June 2013 the MSC amended the SOLAS regulations to require all passengers to undergo a mandatory muster drill prior to or immediately upon departure, instead of within 24 hours, as stated in the previous regulations. This amendment went into force in January 2015. The MSC also updated the long-term action plan and the short-term measures to include recommendations relating to; bridge navigational procedures, securing of heavy objects, stowage of lifejackets, extended use of video for passenger emergency instruction notices, etc. (IMO, 2016).

# 4 General review of passenger ship evacuation issues

This chapter will give an introduction to some of the most common complications in the evacuation procedures of large-scale passenger ships.

## 4.1 Effects of pitching, rolling and incline

Walking speed is an important factor during evacuation (Gwynne & Boyce, 2016). Research teams from all around the world have tried to find correlations between ship-motions, trim, heeling, and the walking speeds of evacuees (see Figure 2).

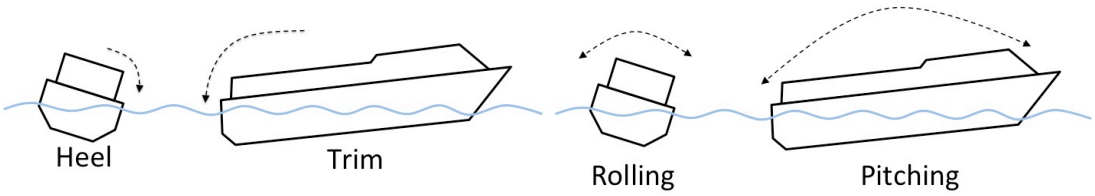


**Figure 2 Heel and trim can be related to as more or less "static" conditions of incline while rolling and pitching are "dynamic" in terms of a back-and-forth rocking motion.**

The studies of Katuhara et al. (1998,1999) describe a research project by the National Maritime Research Institute of Japan that was launched to determine the walking speeds of evacuees. Experiments were carried out during a 3-year period at a ship docked at harbor. The subjects of the experiments were students of 20 years age, in groups of 70-120 persons. By filming the subjects as they moved along a pre-defined evacuation path, the results of the research showed that the average movement speeds of the evacuees were 1.4 meters per second along corridors and 0.7 meters per second for stairs.

The Research Institute of Marine Engineering of Japan has studied the effects of incline as well as pitching and rolling (Yoshida et al., 2000, 2001). In their experiments a total of 20 male and female adults were clocked as they walked through a corridor. The corridor itself was constructed to simulate inclines of up to 20°. For the rolling and pitching experiments, motion cycles of 5 seconds and 10 seconds were simulated, with a maximum incline of 10°. The results of the experiments showed that with no incline, the average walking speed was roughly 1.25 meters per second. For the trim scenarios, the walking speeds varied between 0.82 to 1.38 meters per second – the speed decreasing as the upward trim increased. However, the experiments showed that static heeling up to 20° had insignificant effects on the walking speed. As for the rolling and pitching experiments, the walking speeds decreased by roughly 20% compared to the stationary conditions.

The works of Koss et al. (1997) describes experiments carried out by the Australian Maritime Engineering-Cooperative Research Center (AMEC RC). The 67 participants were males and females in the ages of 18-25. They recorded an average walking speed of 1.65 meters per second for the scenarios without any incline. For downward trim, the walking speed increased as the trim angle increased. For the upward trim and heeling scenarios they found no significant changes in walking speed. However, the studies of Brumley & Koss (2000) showed that listing made a significant decrease in walking speed for people with walking disabilities and for the group of test persons of age 65 and above.

The studies of Bles et al. (2001) describe yet another research-project that was launched to determine how listing and ship motions affect walking speeds along corridors and in stairs. TNO Human Factors in the Netherlands built a ship motion simulator – a 4.0 m x 2.4 m x 2.3 m sized cabin, placed on a hydraulic pump. A total of 150 subjects in the ages of 18-83 participated in the experiments. For the scenarios without any incline, the recorded average walking speed was 1.32 meters per second along corridors. Upward trim resulted in an average decrease in walking speed of 35%, while downward trim and heeling conditions had insignificant impact. For the pitching and rolling scenarios, there was a 15% decrease in speed. In the scenarios where the subjects had to walk stairs, an average walking speed of 0.48 meters per second was recorded under normal conditions – upward trim resulted in a 40% decrease in speed, while downward trim resulted in a 30% decrease. Once again heeling showed no significant impact.
It was also shown that the people in the age group of 60 years and above were roughly 15% slower than the rest of the subjects in most scenarios.

Experimental research similar to the ones mentioned above has also been done at the SHEBA facility by Glen et al. (2003), with similar finings and conclusions.

Due to concerns of safety of the participants, no experiments have examined the effects of incline above 20°. Although most experiments has shown that heeling of up to 20° has insignificant impact on walking speed (for people without walking disabilities), it is plausible to believe that greater heeling will. In addition to having an impact on walking speeds, heavy listing can obviously cause furniture, luggage and other loose items to slide out of place, thereby blocking passages and making the accessibility more problematic. Heavy listing also causes problems in the launching of lifeboats and liferafts, as reported in the case of the Costa Concordia grounding amongst other accidents (RINA, 2016).

## 4.2 Crowd density

Most of the aforementioned experiments on walking speeds do not take into account the effects associated with crowds. In emergency situations, it is sometimes reported that evacuees show tendencies of one or more of the following behavior patterns (Helbing, Farkas, & Tamás, 2000).

- People move (or try to move) faster than they would do under normal circumstances.
- Some individuals start pushing, and interactions among people become physical.
- Moving, and in particular passing of bottlenecks, becomes uncoordinated.
- Fallen or injured people further slow the egress by acting as obstacles.
- People show a tendency of mass behavior, e.g. they adapt the behavior of the surrounding people.

There are a few experiments on crowd movement in ship evacuations. According to the AMEC RC's experiments described by Koss et al. (1997) the crowd movement speed was measured as 1.32 meters per second for the front of the group, 1.10 meters per second for the middle, and 0.80 meters per second for the tail. They also noticed that as two groups from opposite directions met, the speed decreased by roughly 50%. For two groups that first walked parallel to each other and then

merged, the decrease in speed was measured to 20%. Furthermore, the Research Institute of Marine Engineering of Japan found that the crowd movement speed decreased as the width of corridors decreased (Yoshida et al., 2000, 2001). In addition, they found that walking as a crowd was 20–55% slower than walking alone.

The Korea Research Institute of Ships and Ocean Engineering studied crowd movement combined with the effects of ship movement and listing (Lee, Park, & Kim, 2004). For their experiments they built a model of a corridor measuring 10 x 1.2 x 1.9 meters, ending in a set of stairs. The model was constructed to simulate trim angles of -20° to 20° and/or heel angles of 0° to 20°. All experiments were carried out twice – once with, and once without the impact of ship motion. For the ship motion experiments, the whole model was placed aboard a ship and experiments were carried out while the ship was sailing.
The results of their study show that the crowd movement speed was roughly 20% slower compared to the individual movement speed. Substantial decrease in speed was also observed for groups walking in the presence of either trim or heel. When groups of people walking from opposite directions met, there was a significant decrease in speed, especially at the tails of the groups (the walking speed reduction by counter-flow was 30-60%). The presence of ship motions further slowed the egress speed by 10-20%.

## 4.3 Behaviors of people

When disaster strikes, people may react in widely different ways. Leach (1994) suggests that in severe emergencies, only about 10 to 25 percent of people are able to undertake prompt and effective actions. Between 65 to 80 percent of disaster victims are more likely to become indecisive and act in a stunned or bewildered manner. The remaining 10 to 15 percent of victims may display serious maladaptive behaviors such as confusion, crying, paralyzing, anxiety, or even hysteria. This, of course, all depends on the nature of the disaster; under less stressed circumstances the likeliness of calm and orderly responses is obviously much higher compared to situations where time and resources are scarce (Robinson, 2012).

### 4.3.1 Denial

One of the reasons people fail to act appropriately in emergency situations is that some enter a state of denial. “Past experiences of false alarms or inaccurate disaster warnings can lead people, quite rationally, to believe actions are not really needed” (Robinson, 2012). The reliability of the source from which the disaster warnings are coming is also of importance – if people don’t trust the source, denial is more likely. Another contributing reason for denial is that humans are highly social creatures (Robinson, 2012). The deeply rooted desire to not deviate from the norm can sometimes make people ignore any warning signs if no one else is reacting upon it (a form of normative social influence).

### 4.3.2 Freezing

Cognitive paralysis or “freezing” can be observed among people facing disasters (Leach, 2004). In our daily life, humans have a set of pre-planned behavior schemes that we apply for various everyday-situations without much contemplation – given enough time it is also feasible to create new behaviors suitable for most situations (Robinson, 2012). However, when under threat or time-pressure, creating new

behaviors becomes more difficult and may thus result in what we refer to as freezing – leaving a person seemingly paralyzed (Leach, 2005).

### 4.3.3 Stereotypical behaviors

It also happens that people facing disasters are able to avoid freezing by engaging their pre-existing behavior schemes. Although it is less cognitively demanding to use the pre-existing behavior schemes, it may sometimes result in some less than ideal behaviors (Robinson, 2012). One example of stereotypical behavior is when people use their normal every-day exit route or the entrance from which they came in, instead of using the designated emergency exits, even if it means they must walk a longer distance or possibly even pass several emergency exits on their way. This behavior could also be explained using the affiliative model by Sime (1983,1985).

### 4.3.4 Inappropriate behaviors

In addition to freezing and stereotypical behaviors, people facing disasters also tend to make poor decisions that can lead to inappropriate actions (Robinson, 2012). Experimental studies have shown that the combination of time pressure and vague or unclear information is likely to cause errors in people's judgment (Ariely & Zakay, 2001).

### 4.3.5 Memory failures

Victims of disasters often report of memory failures (Robinson, 2012). There are several theories as of why memory problems are caused during pressured situations – one being that the body releases high levels of cortisol hormone, which can affect the memory processing (Robinson, 2012). Regardless of the specific reason behind it, it is obvious that memory failures during disaster situations can cause victims to forget how to follow emergency procedures or how to use specific emergency equipment (Robinson, Sünram-Lea, Leach, & Owen-Lynch, 2008).

## 4.4 Assembling people

The evacuation of large-scale passenger ships and Ro-Ro ferries usually comprise a two-stage procedure, with an *assembly* and an *abandonment* phase. The assembly phase commences as the general emergency alarm is raised, and passengers are instructed to assemble at their muster stations. Depending on the procedures of the specific ship operators, the passengers will either have to collect their lifejackets from their cabins, or otherwise receive them at the muster stations. Normally, crew will be stationed in staircases and in corridors on all decks to guide the passengers, and if necessary, search all areas of the ship for passengers. The Royal Institution of Naval Architects suggests that for a ship the size of Costa Concordia, the assembly phase could take 40-60 minutes (RINA, 2016).

The total assembly time highly depends on a number of factors, such as; response time of the passengers, wayfinding, behavior of people, walking speeds, etc., etc.

As part of the so-called SAFEGUARD project, Galea et al. (2014a, 2014b) has carried out a series of semi-unannounced full-scale assembly trials at various types of large passenger ships in order to collect validation data-sets for ship evacuation software tools such as maritimeEXODUS, i.e. Using IR beacons and tags as well as video cameras, Galea et al. (2014a, 2014b) were able to collect useful information regarding the response times of the passengers. The results from two of the experiments are presented below.

The first assembly trial took place on a large RO-PAX ferry operated by ColorLine AS, called SuperSpeed 1.The vessel has a capacity to carry approximately 2000 passengers and crew and over 700 vehicles. The assembly trial was carried out on the vessel's route from Larvik in Norway to Hirtshals in Denmark, a trip of 3 hours and 45 minutes. At the day of the experiment there were a total of 1349 passengers aboard – out of which 780 wore IR tags and were, thus, registered by the IR beacons. Response times were registered between 0 and 402.4 seconds, with a mean response time of 35.80 seconds and a standard deviation of 2.65 seconds (Galea, Deere, Brown, & Filippidis, 2014a).

The second assembly trial took place aboard a Royal Caribbean cruise ship with a capacity to carry approximately 2500 passengers and 842 crew. Data was collected on the vessel while it was cruising in the Baltic Sea, between Harwich in the UK and Copenhagen in Denmark. The trial involved some 2292 passengers, out of which 1779 wore tags and were thus tracked throughout the trial. Response times were registered between 0 seconds and 1379 seconds, with a mean response time of 150.20 seconds and a standard deviation of 2.44 seconds (Galea, Deere, Brown, & Filippidis, 2014b).

## 4.5 Wayfinding

"A passenger ship can be a labyrinth for people staying onboard. Contrary to crewmembers, passengers are not familiarized with the arrangement of corridors and spaces within the ship" (Lozowicka, 2006). Lozowicka highlights the importance of proper lighting and signage of evacuation routes. As emergency situations can be accompanied by power outage and/or the presence of smoke, it is essential that information about direction of escape is clear and easy to find. Without an emergency way-finding system the potential for slips, falls, injury or fatalities becomes greatly increased, she says. However, as May (2004) points out, "the primary assistance to passengers is given by human agents who have been trained in emergency procedures and evacuation of passengers". This statement is further strengthened by the experiments of Yoshida et al. (2001). May (2004) also explains that a person under stress can easily be confused and misinterpret the various meanings of the evacuation signs. He further implies that the typical 'you-are-here' maps are not very useful under evacuation situations, as these require more time to analyze and interpret.

## 4.6 Disembarking

The abandonment phase begins when the Master gives the abandon ship order. The current SOLAS regulations specify that it should take 30 minutes maximum, to prepare and launch the lifeboats and life rafts from a passenger ship once the passengers are actually assembled. If necessary, the abandonment phase can even start before all passengers have assembled (RINA, 2016). The launching of lifeboats may very well be one of the most critical phases of an evacuation.

# 5 Case study

Accounts of what happened on the night of the Costa Concordia grounding are plenteous in numbers, however there is some divergence amongst them. In order to get a better understanding of the accident, first a brief summary of the various media channels' reports is introduced, followed by an analysis of video recordings from the accident. Thereafter, accounts from survivors are presented, and finally – the results from scientific studies and investigations.

## 5.1 Media's interpretation

Immediately after the grounding, media started reporting worldwide of the 'Costa Concordia disaster'. The reports from the earlier broadcasts and newspapers, e.g. from the first couple of days after the grounding, vary the most. For example, there are several conflicting accounts as of at what time the ship hit the underwater reef; around 8 pm (International Business Times, 2012), 9.30 pm (news.com.au, 2012), 9.44 pm (Financial Times, 2012), etc. Different sources also claim various size of the gash on the portside hull, ranging anywhere between 45 meters (Sky News, 2012) up to 100 meters (Discovery News, 2012). There were also a number of different suggestions regarding how many passengers and crew that were aboard the cruiser at the time of the incident. However, one feature that a majority of the media coverage had in common was the emphasis on scenes of 'panic' and 'chaos'. The examples below are just a few of the headlines and ingress quotes that could be read in newspapers in the days following the Costa Concordia grounding.

*"One hour of panic on stricken cruise liner Costa Concordia"*
(Mirror, 2012)

*"Costa Concordia Disaster Videos: Amateur Footage Shows Passenger Evacuation, Panic"*
(The World Post, 2012)

*"The ship's doctor on the Costa Concordia cruise liner has described scenes of panic and chaos as he helped dozens of terrified passengers clamber into lifeboats as the vessel keeled over."*
(The Telegraph, 2012)

*"Passengers tell of 'chaos' as crew members said 'go back to your cabins'"*
(Daily Mail, 2012)

*"There were scenes of panic as the Costa Concordia hit a sandbar on Friday evening…"*
(BBC, 2012)

*"Passenger videos show panic after wreck of Costa Concordia cruise ship…"*
(Daily News, 2012)

In the months following the accident, the media mainly focused on updating the rising death count, and on publishing passengers' stories (which will be further presented in Section 5.3), as well as speculating on theories regarding the Captain's maneuvering and actions after the initial impact.

The following photos show the cruise ship Costa Concordia, as it lies docked at harbor (Figure 3), and after the capsizing, as the search and rescue operation is set in motion (Figure 4).


**Figure 3 The Costa Concordia cruise ship (image retrieved from Wikimedia Commons, photo: Cezary Piwowarski)**

**Figure 4 The Costa Concordia after it is severely listed (image retrieved from Wikimedia Commons, photo: Roberto Vongher)**

The photos below were taken on the 14th of January 2012, Figure 5 illustrating the continued search and rescue operations, and Figure 6 showing the 53 meter rift as well as the rock embedded within the portside of the hull.

**Figure 5 The lifeboats have reached the port of Isla Giglio while rescue teams are still searching onboard the ship (image retrieved from Wikimedia Commons, photo: Roberto Vongher)**

**Figure 6 The impact with the reef tore a 53-meter long hole to the portside of the hull. A big rock was detached from the reef and got stuck in the hull of the vessel (image retrieved from Wikimedia Commons, photo: Roberto Vongher)**

## 5.2 Observations made from video- and mobile phone recordings

There is a variety of video footage from the Costa Concordia disaster to be found on You-tube and other online media channels, filmed by passengers and crew utilizing mobile phones and amateur camcorders. However there is also a wide range of "fake" video footage circulating – claiming to be recordings from the Costa Concordia grounding – that are essentially filmed in entirely different situations. It has therefore been of uttermost importance to verify the sources the video recordings in order to sort out irrelevant material.

On the 11th of April 2012, the British Channel 4 broadcasted a documentary called *The Sinking of Costa Concordia: Caught on Camera*. The documentary includes a thorough compilation of private video recordings supplied by passengers and crew. Conveniently the editors of the documentary have made great effort to align the video footage in consecutive order and to provide accurate time of events, allowing to get a better understanding of the different phases of the disaster. In addition to the private recordings, the documentary also includes some video material supplied by the coast guard and rescue divers.

The Channel 4 documentary has formed the basis for the video analysis of this thesis, as nearly all of the elsewhere retrieved video recordings are included therein. The observations therefore refer to *The Sinking of Costa Concordia: Caught on Camera* (Cheslin-Nuttall, o.a., 2012). Comments on the various behaviors observed are presented in the tables below.

In order to better understand the characteristics of the different phases of the evacuation, comments have been categorized into behaviors observed and divided into groups corresponding to the sequences described.

| **Initial sequence (approx. 21:45 – 22:33)**<br>- The time between the first impact until the general emergency alarm is raised. | |
|---|---|
| **Behaviors** | **Observations from video recordings** |
| Confusion | Immediately after the impact there is great confusion amongst the people onboard, neither passengers nor crew knows what is happening. |
| Yelling, shouting | There is an initial state of turmoil and some people are yelling and shouting. |
| Anxiety | At first most people seem very anxious and leave their seats in the restaurants to head for the nearest exits. |
| Hesitancy, indecisiveness | Immediately after the impact, the waiters and staff are trying to calm the passengers, but they seem insecure of how to handle the situation and are giving conflicting orders. Some suggest that it is best to just sit down and wait, while others are urging the passengers to proceed to the exits. |
| Crying | There are young children crying as plates and glasses are falling to the floor, asking their parents what is going on. |

| | |
|---|---|
| Calming, soothing | Parents are acting calm, trying to sooth their crying children and say that there is nothing to worry about and that everything will be fine, proposing that it is just a matter of a broken engine. |
| Calm | A public announcement is made, stating there is a power outage and the public is ensured that the situation is under control. Thereafter, the majority of people are acting relatively calm, although many are still skeptic. Some of the kitchen staff and waiters are cleaning up the mess in the restaurants as if the order would soon go back to normal. |
| Humor | As people are leaving the restaurants, a few are jokingly saying that they hope the cruise company will pay for their wine bills, others are heading for the bar to ask if it is still open for business. |
| Leadership | Crewmembers are urging the passengers to stay calm and ensuring that the situation is under control. After a while the passengers are asked to return to their cabins or to sit down in any of the public lounges. |
| Skepticism | Some passengers are questioning how the ship can be listing, presumably "only" due to a technical fault and ask why the crewmembers are wearing lifejackets since they claim everything is under control.<br><br>As the listing of the ship increases, more and more people gather by the muster stations. There are obvious difficulties in walking normally along the tilted corridors.<br><br>A recording filmed on the bridge reveals a conversation about passengers trying to enter the lifeboats on their own, despite the instructions from the crew. |

| **Main evacuation sequence (approx. 22:33 – 00:00)**<br>- The time after the general emergency alarm until the lifeboats on the portside of the ship can no longer be launched due to the listing. | |
|---|---|
| **Behaviors** | **Observations from video recordings** |
| Stress | When the general emergency alarm is eventually announced, the people that are not already gathered at the muster stations hurry to get their lifejackets and rush to the muster stations as they realize the situation is worse than previously assumed. |
| Anxiety | The passengers at the muster stations look worried and many are quiet and anxious. |
| Humor | Some crew and passengers are trying to keep the spirit up and are making jokes and filming each other as they are balancing back and forth across the tilted deck to pass the time. |

| | |
|---|---|
| Calm | Although there is a mixed state of mind aboard the ship and many are scared, the majority of people are acting calm as they are waiting for further instructions. |
| Competitive behavior (pushing, elbowing, squeezing) | When the crew finally allows passengers to enter the lifeboats, turmoil breaks out as some are trying to push and elbow their way forward to get aboard the lifeboats. Some of the people that are being squeezed and pushed are upset and there is screaming and shouting. |
| Goodwill | Old people with walking disabilities and families with young children are given priority by most and are being helped aboard the lifeboats, although there are still some ignoring this manner, who still try to force their way forward. |
| Leadership | The crew is trying to direct the evacuation and keep the passengers calm, but due to the competitive behavior shown by some people they are having difficulties in retaining the order. |
| Insecurity | Apart from the fact that the listing makes it difficult to launch the lifeboats, some of the crewmembers are seemingly insecure of how to release and/or maneuver the lifeboats. |
| Screaming, shouting | During the launching of the lifeboats, there is much yelling and shouting from both crew and passengers. Some of the passengers are screaming, seemingly afraid, as boats get stuck on the way down the side of the ship. Crewmembers are shouting at each other in attempts to communicate with the people in control of launching the boats. With all the loud noise, there are difficulties in the communication. |
| Fear | There are unmistakable signs of fear aboard the lifeboats as they are being launched. One crewmember falls outside one of the boats before his colleagues are helping to pull him back up. People are screaming and crying. |
| Patience | The people that do not fit on the first couple of lifeboats begin to make their ways to other areas of the ship to see if they have better luck elsewhere. Some passengers show signs of frustration while others are patiently waiting for their turn. |
| Relief | As the lifeboats finally reach the water, people are able to relax a bit more and there are spontaneous applauds and cheers of relief. However they are soon thereafter asked to quiet down in respect to the passengers still aboard the cruise ship. |

**Latter sequence of evacuation and search/rescue operation (approx. 00:00 →)**
- The period between the severe listing that made launching of lifeboats impossible on the portside of the ship, until the rescue operations were suspended.

Unfortunately it has been proven extremely difficult to find any video footage covering the latter sequence of the evacuation – or more specifically, any material suitable for the purpose of this analysis. The recordings available of the latter sequence are mainly filmed from a distance by the coast guard's helicopters and others outside the ship. The distant perspectives and low resolution of the footage makes it difficult to observe any specific behaviors.

As time elapses, the listing of the ship comes to such a degree that launching of the lifeboats is no longer possible. Video footage from the rescue helicopters show that there are some people in the water, swimming for the beach, while many are still stuck onboard, some climbing down rope ladders to assisting rescue boats, others clinging on to the highest points they can reach.

The divers that searched the ship in the days after the grounding filmed some of the scenes featured at the end of the documentary. Their footage shows stacks of furniture and other obstacles scattered all over, which also may have complicated the evacuation.

There are several plausible explanations for the lack of close-up videos of the latter evacuation sequence. It may for example be that the increased listing of the ship made any filming too difficult. Or it may also be that the individuals that were actually filming anything were already evacuated, as the majority of people were by 00:00 hrs. Again, these possible explanations are only assumptions.

## 5.3 Accounts from survivors

There are copious amounts of information from survivors regarding the evacuation of the Costa Concordia, however their accounts are often fragmentary. The freshness of the passenger statements also vary, some were released shortly after the accident and others were not published until months or even years later, which may have had an impact on the stories told. It is also to be noted that a person's definition of fear and panic may vary largely between individuals. A significant amount of accounts from passengers and crew have been studied and analyzed for this thesis but only a handful of representative comments are presented below, as the amount of material would otherwise be tremendous.

Several passengers witness of scenes of panic and fear, but claim that they stayed relatively calm themselves. Others mention that the atmosphere onboard was generally calm during most part of the evacuation, until the listing of the ship increased severely and caused problems in the launching of lifeboats. One major issue that many of the passengers enlighten is the lack of communication, including language barriers as well as conflicting orders from the crew.

In order to better understand the characteristics of the different phases of the evacuation, comments have been categorized into behaviors observed and divided into groups corresponding to the sequences described.

| **Initial sequence (approx. 21:45 – 22:33)**<br>- The time between the first impact until the general emergency alarm is raised. | |
|---|---|
| **Behaviors** | **Comments from passengers and crew** |
| Panic | Passenger: "There was just complete and utter chaos and panic. No one from the crew seemed to know what they were doing. It was just like something from the Titanic. Some of the crew were telling us to go back to our cabins while others were saying go to the life boats - it was obvious we were in serious trouble because we heard a terrible scraping noise." (Daily Mail, 2012)<br><br>Passenger: "We were having dinner aboard when we heard a loud noise, like that of the keel being dragged over something. The lights went out and there were scenes of panic, glasses falling to the floor." (Daily Mail, 2012)<br><br>Fabio Costa, ship's shop assistant: "Everything just started to fall, all the glasses broke and everybody started to panic and run." (The Telegraph, 2012a)<br><br>Michelle, passenger: "After the ship Hit it listed people rang and panicked we were told to go to our rooms". (Michelle, 2012)<br><br>Passengers: "Everything happened really fast. All of a sudden we felt the boat hitting something and everything just started to fall, all the glasses broke and everybody started to panic and run. I was under impression |

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|---|---|
| | that all of us were going to finish into the water. Panic spread through the ship. We were trying to find our daughter, but we did not find her, neither in the playroom nor in the theatre. Our search continued for the next hour and a half." (Lasić, Žuljan Cvitanović, Uglešić, & Dodig, 2012) |
| Screaming, shouting | Fernando Tofanelli, passenger: "Plates and tables were flying all over the place and people were falling over as the tilting got worse. People were shouting and screaming and it was absolute chaos." (The Telegraph, 2012a) |
| Competitive behavior (trampling, scrambling) | Passenger: "We're sitting at our dinner table when there was a loud bang and things just flew off the table. The lights went off and then came back on again and then everyone just started scrambling over each other to try and get a life vest or to the life boats. People were trampling over each other and children in the chaos." (Daily Mail, 2012) |
| Leadership | James Thomas, ship's dancer: "We had an announcement saying please stay calm, everything is under control, it's just a minor technical fault. Then we had the coding of two short blasts followed by alternate tones which means there is a leak on board and so the crew were divided, very much so. A lot of people said, 'no just tell everyone to stay calm, that's what we've been told to say'. But then other people took the initiative and said, 'Okay, let's tell everyone to stay calm but hand over life jackets'." (Mirror, 2012)<br><br>Fernando Tofanelli, passenger: "While we were still in the dining room, the crew basically disappeared, and it was left to a few Thai waiters who didn't speak English to try to keep us calm." (The Telegraph, 2012a)<br><br>Alberto Fiorito, ship's engineer: "We didn't wait for the captain to give the order to abandon ship. We saw how serious the situation was, and we did it ourselves." (The Telegraph, 2012a)<br><br>Michelle, passenger: "The announcements were that we had electrical problems everything was under control, the English was announced by our international host. We were told this twice and then by the staff numerous times, I think they believed it as well." (Michelle, 2012) |
| Humor | Michelle, passenger: "Cabin staff told us not to get our life jackets it was not necessary we sat on stools and the floor joking with them, this went on for what seemed like an hour, the boat struck just after 9pm I think." (Michelle, 2012) |

| **Main evacuation sequence (approx. 22:33 – 00:00)**<br>- The time after the general emergency alarm until the lifeboats on the portside of the ship can no longer be launched due to the listing. | |
|---|---|
| **Behaviors** | **Comments from passengers, crew, and rescuers** |
| Panic | James Thomas, ship's dancer: "It was initial panic but then the majority of us went, 'Okay, we've got to do this, we've got to pay attention to what we're doing"'. (Mirror, 2012)<br><br>Mario Pellegrini, deputy mayor of Isola del Giglio: "There was one mother who was holding a baby. I said, 'Give me the child and I will put him on board the dinghy and then I will give you him back'. But the mother didn't want to, she was panicking and wouldn't let go of the baby. It was very difficult to get the baby from her." (BBC, 2012)<br><br>Fernando Tofanelli, passenger: "The crew left it until the very last moment to begin boarding people onto lifeboats. As a result, precious time was lost, and in the panic people began jumping into the water." (The Telegraph, 2012a)<br><br>Monique Maurek, passenger: " There was a panic and my husband pushed me into a lifeboat to make sure I got on. Other people fell on top of me and I was screaming. People were falling out of the lifeboat in front of us down into the water." (The Telegraph, 2012a)<br><br>Phoebe Jones, ship's dancer: "The ship went on a huge, huge lean. Some people started to panic, but I was fine. Even though I was so scared I still didn't really get what was going on." (The Telegraph, 2012a) |
| Confusion | Mario Pellegrini, deputy mayor of Isola del Giglio: "At the beginning there wasn't much panic, just a lot of confusion. People didn't know what to do but there was no real fear. There were a lot of people who wanted to help but there was no-one guiding them; there was nobody was directing anything. There was goodwill by many people but many didn't even speak English, so it was difficult." (BBC, 2012)<br><br>Nancy Cacopardo, passenger: "The crew were all Asian and it was very hard to communicate with them. They were trying to help us and working hard to get us off, but there was so much confusion."<br>(The Telegraph, 2012a) |
| Competitive behavior (pushing, forcing) | Fernando Tofanelli, passenger: "After about an hour the ship finally sounded several blasts on the horn, and that was the signal to go to the lifeboats, but by then people were pushing each other to get out of the way, and some were leaping over the side into the sea. They didn't have enough lifeboats for all the passengers because some appeared to be underwater from the ship leaning over." (The Telegraph, 2012a) |

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| | Fabio Costa, ship's shop assistant: "People panicking and pushing each other didn't help at all. So we were all trying to keep people calm but it was just impossible, no one knew what was going on." (The Telegraph, 2012a)<br><br>Edwin Gurd, passenger: "I was getting a bit disturbed about how a few male passengers were trying to force their way on to the lifeboats." (The Telegraph, 2012a)<br><br>Michelle, passenger: "We got into the boats we had a waiter in the drivers seat and some boys in white overalls, the lifeboat filled to capacity and they shut the door, people screamed the door was pushed open and people continued to enter the boat overflowing it…" (Michelle, 2012)<br><br>Passengers: "Everybody tried to get a lifeboat and people started to panic. A lot of people were falling down the stairs and some were hurt because things were falling on them. Everybody was trying to get on the boats at the same time and they were pushing each other." (Lasić, Žuljan Cvitanović, Uglešić, & Dodig, 2012) |
| Disbelief in leadership | Fernando Tofanelli, passenger: "Some of the crew didn't seem to even know how to release the lifeboats or even start the lifeboat engines once they were down on the water. The crewman in charge of our lifeboat was absolutely ashen-faced, he just didn't know what to do." (The Telegraph, 2012a) |

| **Latter sequence of evacuation and search/rescue operation (approx. 00:00 →)**<br>- The period between the severe listing that made launching of lifeboats impossible on the portside of the ship, until the rescue operations were suspended. | |
|---|---|
| **Behaviors** | **Comments from passengers, crew, and rescuers** |
| Panic | Mario Pellegrini, deputy mayor of Isola del Giglio: "Then I went on the right-hand side of the ship and it started tilting towards the sea. Big parts of the ship were going underwater - then panic erupted, people really were scared." (BBC, 2012)<br><br>Rose Metcalf, ship's dancer: "We knew there would be too many people for the life rafts. We were literally throwing each other. We were creating human chains to try to pass people over gaps that if they dropped down there was no recovery from. There was panic, people were white – crying and screaming. I decided to wait until the water was high enough so I could jump or swim, but I didn't want to be inside. (The Telegraph, 2012a) |

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| | Passengers: "It was a real horror! Every second we feared of the worst happening! We are still not aware of what we experienced during the accident. We do not believe that this could happen. We are constantly ruminating pictures of people struggling for life, blood, panic, fear, crying... All of us still have nightmares." (Lasić, Žuljan Cvitanović, Uglešić, & Dodig, 2012) |
| Fear, crying | Mario Pellegrini, deputy mayor of Isola del Giglio: "When the boat started listing, all the corridors filled with water. They were like wells and there was a lot of people stuck in these wells. Using a rope, I started to pull people up. They were crying and were really scared." (BBC, 2012) |
| Screaming, shouting | Mario Pellegrini, deputy mayor of Isola del Giglio: "While I was pulling people out of the upended corridor, one girl started shouting and pulling and we had to take her out by her feet." (BBC, 2012) |
| Freezing | Mario Pellegrini, deputy mayor of Isola del Giglio: "A lot of the old people attached themselves to anything they could find and they didn't want to let go so we had to go down and detach them finger by finger." (BBC, 2012) |
| Competitive behavior (fighting, crushing, scrambling, pushing) | Mario Pellegrini, deputy mayor of Isola del Giglio: "People were fighting with each other in order to get on the rope to climb up. I can't condemn them because the situation was really bad. It was really dramatic." (BBC, 2012)<br><br>Ian Donoff, passenger: "There was this mad scramble for a ladder: people got crushed pushed and goodness knows what – it was like a free for all… Children seemed to be treated with some sort of reverence, so they were pushed up quicker, but apart from that it was hell." (The Telegraph, 2012a) |
| Calm | Ian Donoff, passenger: "Some people were freaking out, others were staying incredibly calm." (The Telegraph, 2012a) |
| Leadership | Mario Pellegrini, deputy mayor of Isola del Giglio: "Then, on the bridge, I came across the only officer I could find. He was young, a second-class officer… We were together shoulder to shoulder until 05:30 in the morning. I have to say this young officer was wonderful. He hadn't been given any orders; he was just following his own orders." (BBC, 2012)<br><br>Ian Donoff, passenger: "The lifeboat crews took over and they were fantastic. They lifted people onto their boats before transferring them to other lifeboats to the mainland and evacuating them away from the ship." (The Telegraph, 2012a)<br><br>Rose Metcalf, ship's dancer: "I was making sure the people on my life raft had their jackets done up. I was trying to keep people talking, was |

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| | trying to keep the mood calm and keep practical. My heart was racing, but I was calm to everyone else." (The Telegraph, 2012a) |
| Heroism | James Thomas, ship's dancer: "I was willing to give my life to make sure they (passengers) reached safety. I know a Bulgarian engineer, he swam with an Indian man on his back because he had no life jacket and had injured himself. Some of the stories are phenomenal... you just see people's true nature and how caring everyone was for people on board… It's crazy because it's not in my character to even think that I could do any of those things that I did, but I managed to pull myself together and help people and be helped myself by another passenger and I couldn't thank him any more." (Mirror, 2012)<br><br>Mario Pellegrini, deputy mayor of Isola del Giglio: "It was a purser of the ship who was helping me and we rescued about nine people. Some of them were quite old; some of them were children…The doctor also helped me; he was very good and courageous." (BBC, 2012)<br><br>Nicole Servels, passenger: "For an hour we had waited in line to get into a lifeboat – my husband let everyone else go first … I can't swim so he gave me his lifejacket. He shouted, 'Jump, jump, jump!'. I froze and couldn't jump, but he jumped off the ship and shouted upwards, 'Come on, don't worry'. I jumped off and the last thing I heard him say was that I would be fine. I never saw him again." (The Telegraph, 2012a) |

## 5.4 Scientific studies and investigations

This section constitutes information gathered from studies and investigations that have been peer reviewed, and hence achieved a scientific status.

### 5.4.1 Evacuation analysis by David E. Alexander

Roughly one month after the disaster David E. Alexander wrote a paper on the Costa Concordia grounding by the title: *The 'Titanic Syndrome': Risk and Crisis Management on the Costa Concordia*. In his paper Alexander reconstructs the sequence of events before, during and immediately after the event, based mostly on secondary sources such as the media, video recordings, and marine data etc. The paper also considers how real-time management of the crisis affected the evacuation of passengers, staff and crew from the liner. Furthermore, he makes comparisons with some other well-known maritime disasters to show that the Costa Concordia incident had various key elements in common with these. The following timeline of events is derived from Alexander's report:

13.01.2012

- At 19:33 the Costa Concordia sets sail from the port of Civitavecchia.
- At 21:30 the 'salute' approach to Isola del Giglio is set in motion.
- At 21:45 the ship strikes a rock, traveling at 15 knots.
- Between 21:45 - 21:55 the ship decelerates to 0 knots and turns more than 180 degrees.
- At 21:56 the ship comes to rest on the shore of Isola del Giglio.
- At 22:12 officers make contact with Port Authority of Livorno.
- At 22:15 the passengers are advised to return to their cabins.
- At 22:26 the Master requests the assistance of a tug.
- At 22:42 the Master admits to Port Authority that the situation is critical.
- At 22:45 ad hoc unofficial evacuation begins; the main evacuation lasts until about 01.45
- At 22:58 the Master gives the general order to evacuate.

14.01.2012

- At 01:30 the Master abandons the ship
- At 01:45 the harbor Master of Livorno 'orders' the Master of Costa Concordia to return to the ship (which he does not)
- At 03:45 six hundred passengers are evacuated from Isola del Giglio to the mainland by ferry.
- At 05:30 the last senior officer abandons the ship while a few tens of people are still left on board

15.01.2012

- At 07:30 the last living person (a crew member) is evacuated from the ship; the search for bodies continues for more than one month.

By the time Alexander's analysis was published, 15 people were confirmed to be dead and another 17 bodies were still missing.

In his paper, Alexander carefully declares that his work is "pieced together on the basis of careful comparison between many documents originating in different countries and from diverse sources", but that he cannot guarantee the accurateness of the information. To statue an example of his apprehensions being justified; in the paper Alexander suggests that the ship had a total of 3229 passenger on board at the time of the accident, this however deviates from what was later stated in the official investigation report; 3206 passengers (refer to section 5.4.3). Furthermore Alexander also wrote that the impact with the rock left an "about 70 meters long and up to 48.8 meters wide" gash on the port side of the hull. The latter information is clearly exaggerated as the official investigation report confirmed the gash to be 53 meters long. This once again proves that information retrieved from the media can be delusive.

The pieced-together narrative is followed by Alexander's interpretations and analysis of the event. His understanding is that the first official reaction on the bridge after the collision was to minimize the communications with the public. The impact was accompanied by a loud boom and groan noise, after which the ship jolted and rapidly decelerated, throwing objects around on board. The passengers were told over the public address system that the ship had a technical fault, but that the situation was under control. The passengers were also advised to either go back to their cabins, or go for a walk. A hiatus of direct leadership thereafter led to that a significant amount of time was lost between the initial collision and the start of the evacuation. Alexander notes that when the disembarking procedure of the ship was finally set in motion, the heavy listing of the ship made the evacuation hazardous and caused great difficulties in the launching of lifeboats and rafts. He also makes comment (based on video footage and interviews) on the sporadic scenes of 'panic' that erupted amongst some of the passengers:

> *"…there are clear indications of panic, competitive behavior and chaotic reactions on the part of evacuees. Nonetheless, the panic was swiftly mitigated by spontaneous leadership and the level-headed behavior of some passengers. This confirms the findings of more than half a century of sociological literature on panic; namely, that it is an uncommon, transient and short-lived phenomenon that is usually a reaction to specific circumstances, principally fear of immediate entrapment. Hence, as the literature and available evidence would indicate, on the Costa Concordia panic was not particularly widespread and, as is commonly the case, it was not a major factor in changing the social processes of evacuation."*

The evacuation of the Costa Concordia was largely led and directed by entertainment and hospitality staff, Alexander says. He also states that many of them appeared to lack adequate training in the necessary evacuation procedures. Furthermore he makes notice of the problems caused by language barriers as several of the staff members that tried to lead the evacuation had scarce knowledge of English, or none of Italian (which was crucial as a majority of the passengers were of Italian origin). Alexander proposes that the combination of the increasing listing and the lack of adequate command and diligence caused a climate of frustration and competitive behavior among the passengers on board.

To finish off the evacuation analysis, Alexander says there is a general assumption that "information which is either alarming or uncertain will lead to maladaptive behavior, usually of a chaotic, competitive nature … on the other hand, giving passengers misleading information could easily lead to preventable deaths and injuries."

To summarize Alexander's conclusions of the Costa Concordia evacuation sequence, there are obvious signs of breakdown in the chain of command, which lead to avoidable chaos and competitive behavior among the passengers. The consistently poor communication with passengers and the fact that the evacuation process was supervised by poorly trained staff invoked risky procedures that could easily have ended with more casualties.

(Alexander, 2012)

### 5.4.2 Passenger evacuation review by RINA

The Royal Institution of Naval Architects (RINA) has published a review of the passenger evacuation of Costa Concordia on their website.

RINA first of all made notice, that out of the 3206 passengers aboard, 696 persons had not yet taken part of the muster drill at the time of the accident. They also point out the bridge's severe lack of understanding and sharing of information regarding the extent of the damage. E.g., within 10 minutes of the initial impact, the Chief engineer had informed the personnel on the bridge about flooding in two of the watertight compartments, and within 25 minutes it was confirmed that at least four WTC's were breached (Marine Casualties Investigative Body, 2013). When the Master after 35 minutes asked the bridge staff about how many compartments that were affected, the response was "three compartments flooded". In reality, a total of six compartments were already breached.

Furthermore, RINA express their strong disapproval of the delay of the disembarking procedure. Their opinion is that even if assuming that only two of the WTC's were flooded, the appropriate response would be to immediately sound the general emergency alarm to get the passengers to their muster stations, in preparation for a safe and orderly evacuation. Instead, the first announcement to the passengers was that the ship suffered a blackout due to an electrical fault.
At some point it would have been fairly obvious that the ship suffered from more than just an electrical fault – as of why many of the passengers and crew put on their lifejackets and assembled in the lifeboat areas, long before the general emergency alarm was raised.

RINA continue their evacuation review by highlighting some additional issues that may have had a significant impact on the protraction of the evacuation:

*"Apparent lack of co-ordination and direction from bridge team to crew involved in safety issues hindered the management of the general emergency and abandon ship phases and contributed to initiatives being taken by individuals. Some of this poor communication seems to have been put down to the lack of wireless telephone system between the key personnel involved in the emergency."*

They also comment on the possible lack of understanding and/or training of some of the crew about their individual roles and responsibilities in an emergency:

> *"Some of the officers in charge of the lifeboats either did not possess the correct safety certification or their certificates had expired. The majority of the crew were Filipinos, Indian, and Indonesian. In total the crew was made up of 38 different nationalities. Not all the crew were able to understand the emergency instructions in the ships working language (Italian)."*

RINA notes that many passengers were ready to board the lifeboats early on in the evacuation process, but were prevented from doing so by the crew who were awaiting the captains abandon ship order. They suggest this may have contributed to the unrest reported by the passengers in the assembly areas. They also speculate that some officers may have started organizing an evacuation even before the captain gave his order.

(RINA, 2016)

### 5.4.3 Official investigation report

On May 23, 2013 the Marine Casualties Investigative Body released a thorough investigation of the Costa Concordia disaster on assignment from the Italian Ministry of Infrastructures and Transports. A large portion of the investigation focuses on the navigational aspects leading to the accident, this is outside the scope of the thesis and will not be further discussed in this report. However, some of the more significant events that took place thereafter are presented below in chronological order. A short summary of the events is also illustrated in Figure 7.

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- At 21:45:07 (according to the AIS) the Costa Concordia cruise ship crashes with it's portside of the hull into a large underwater rock, east of the islands "Le Scole". Soon thereafter the power onboard goes off. The emergency batteries are turned on, but they are only supplying the emergency lighting and internal communications. Six minutes after the impact it is discovered that the hull has a breach. The ship begins to list towards the portside.
- At 21:54:47 a blackout is announced on board and the passengers are reassured that the situation is under control.
- At 22:06 the MRSC Livorno is contacted by the Carabinieri of Prato who reports that they have received a phone call from the mother of one of the Costa Concordia passengers. Apparently the passengers had been ordered to put lifejackets on after a portion of a ceiling had collapsed.
- At 22:11 the ship is practically motionless and begins to drift, and shift the bow to starboard.
- Between 22:10 and 22:15 the list goes from the portside to the starboard side.
- At 22:22:22 the ship contacts the operations room of Civitavecchia Coast Guard, asking for the assistance of two tugs due to a breach. It is also reported that the situation is under control and that there are no injured or missing people.
- At 22:25 MRSC Livorno contacts the Master of Costa Concordia. He reports that the ship has a hull breach on the portside of the ship. He also

communicates that the flooding is causing a gradual heel and that there are dead or injured people on board. Again he asks for the assistance of tugs.

- At 22:29:24 the Chief Engineer reports to the bridge that the board power, the communications, and the Martec system are out of service. Meanwhile, the water continues to rise and flood through the fire doors at deck 0. The water has also reached the aft elevators, kitchen and buffet preparation areas.
- At 22:30:08 some passengers start to enter the lifeboats although the bridge has not yet announced neither the abandon ship order, nor the general emergency alarm.
- At 22:33:26 the general emergency alarm is raised. The passengers are informed that situation is under control.
- At 22:36:05 the Master makes the first announcement to the passengers to go to the muster stations.
- At 22:36:34 MRSC Livorno contacts the ship again. The bridge reports that the heeling is increasing. The Master also notifies to have 3208 passengers on board (in reality 3206) and 1023 crewmembers (in each case a different number from what was stated at the Port of Civitavecchia on departure: 3216 passengers and 1030 members of crew).
- At 22:39 a patrol boat informs MRSC Livorno to have come alongside the cruiser, and that the ship looks visibly down by the stern.
- At 22:49:57 the Second Master orders to prepare the first lifeboats at starboard side.
- At 22:50:08 the Master order lifeboats 1,3,5,7 at sea.
- At 22:51:15 the Master informs the bridge to raise the abandon ship order.
- At 22:54 the Second Master communicates the abandon ship order in English through the public address system.
- At 22:55 UCG Civitavecchia receives a call from the local State Police who reports that the ship is launching the lifeboats with passengers on board (in fact, the abandon ship operation must have already been in place for some time as the patrol boat simultaneously warns rescue boats to pay attention as there are already three lifeboats in the water).
- At 22:58 the cruiser is practically still in it's final position.
- At 23:10 the patrol boat reports to MRSC Livorno that the lifeboats are heading for the south harbor of Giglio island, the life rafts however, are being towed and placed alongside the ferry "Aegilium".
- At 23:11 the list of the ship is more than 25-30°.
- At 23:16:36 the Master orders everyone one the bridge to bring the radios and go to the bridge lifeboats.
- At 23:19:34 the bridge is abandoned except for the Second Master that stays to coordinate the evacuation.
- At 23:32:56 the Second Master also leaves the bridge.
- At 23:35 MRCC Rome contacts the FCC who announces that the abandonment is almost complete.
- At 23:38 MRSC Livorno contacts the Master by phone, he reports that there is still an estimated 200/300 people left on board including passengers and crew. This number is confirmed (300/400), by the patrol boat.

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- At 00:00 the scenario changes. The cruiser rapidly lists towards the starboard side, to such a degree that there are significant difficulties in embarking life-saving appliances on the portside, thus creating three large groups of people (at the bow, center and stern of the ship). Some people are seen jumping into the water. In view of the simultaneous presence of shipwrecked at sea and the need to search and recover even within the now submerged part of the ship, MRSC Livorno dispose the activation of the diver teams.
- At 00:18 the OSC reports that there are about a hundred people on the portside of the ship. Three minutes later the OSC also mention that several passengers, in panic, has begun to jump into the water.
- At 00:34 MRSC Livorno contacts the Master of the Costa Concordia on his cellphone. He refers about the landing of all persons on board. To the requests of clarifications relating to what is happening on the portside, the Master declares that he is on board a lifeboat on the opposite side; he also reports that it is engaged in the recovery of some survivors. When asked about who has remained on board to coordinate abandon ship operations, he replies that the entire crew has evacuated.
- At 00:36 a patrol boat reports to MRSC Livorno that there are at least 70/80 people left on board the ship, including elderly and children, this information is also confirmed by a helicopter.
- At 00:41 the FCC calls MRCC Rome to ask for assistance as the ship is completely listed (90 °) to the starboard side, and that there are about 50 people left that are no longer able to leave the ship.
- At 00:42 MRSC Leghorn contacts the Master of Costa Concordia who says that there seems to be a hundred passengers left on the ship.
- At 00:53 helicopters are set in to rescue the people still on board the ship.
- At 01:35 the OSC updates MRSC Livorno about the situation and passes on the information from a passenger who claims that there are still about 400 people on board assisted by crewmembers disembarking on the portside.
- At 02:00 a patrol boat takes on board the first team of firefighters with thermal cutting equipment (to release any people trapped inside the ship).
- At 03:44 there is still an estimated 40/50 people left on board.
- At 04:20 the OSC updates the situation, they are still disembarking people through the aft side ladder.
- At 04:30 MRSC Livorno orders the Safety Officer, with a team of firefighters, to assist the rescuers aboard in the search for the missing people.
- At 05:15 another team of firefighters board the ship to see if there are still people trapped on board, shortly thereafter they recover two traumatized.
- At 06:17 the first rescuers suspend their search operations on the ship.

In the following days the search and rescue operations continued with the use of the Coast Guard's divers team, Police, Navy and Fire Department. Three more people that were trapped within the ship were recovered and rescued by divers on 14th of January, more than 24 hours after the accident. The search of survivors at sea continued with the patrol boats of the Coast Guard and of the other government departments that contributed in the rescue operations as well as by helicopters.

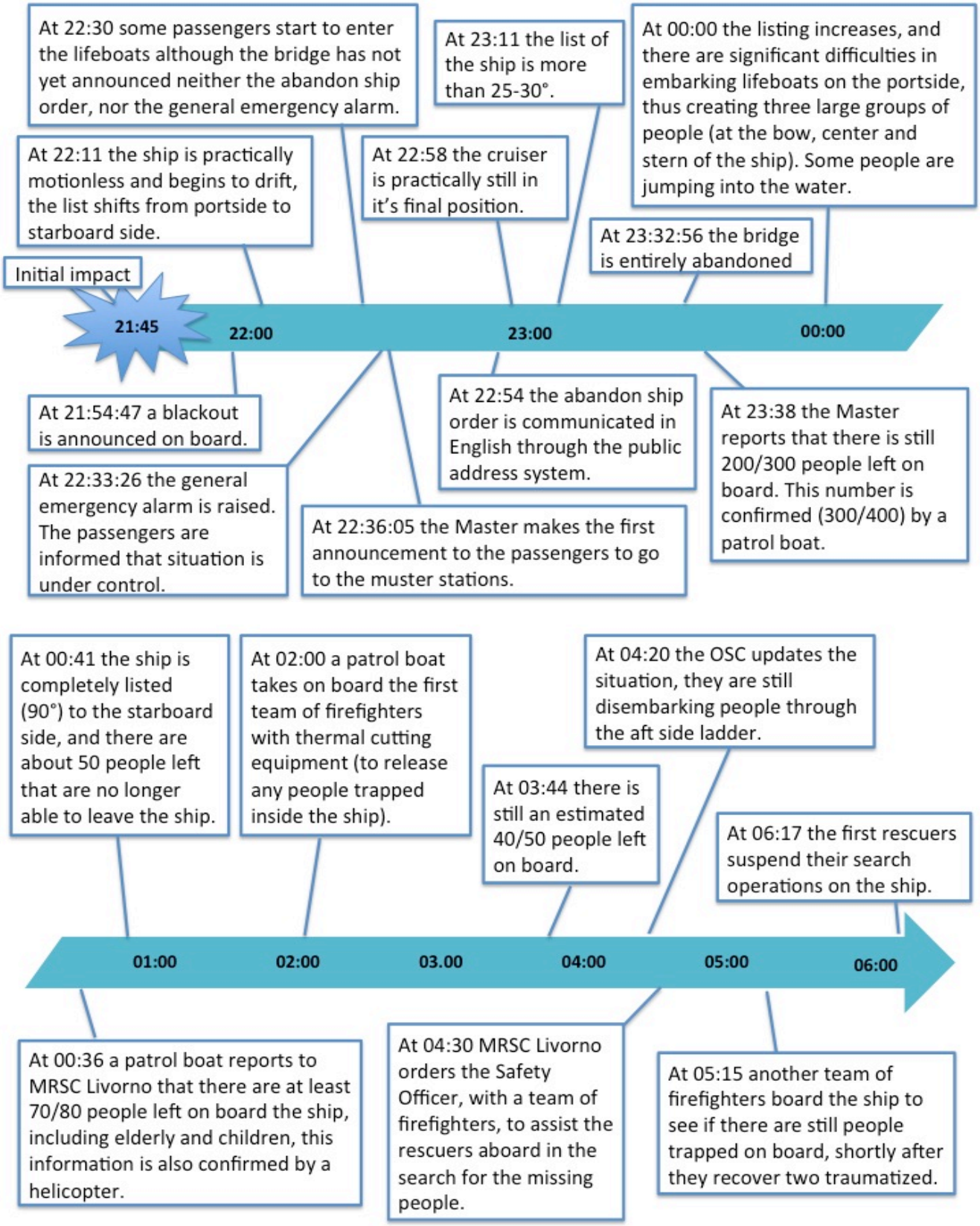


**Figure 7 A summary of the time-line obtained from the official investigation report illustrates some of the most significant events of the disaster**

The complete passenger data, which was later supplied by Costa Cruises, indicate that there were a total of 4229 people on board the ship at the time of the accident, including 3206 passengers and 1023 crew. Out of the passengers, there were 2954 adults, 200 children (under 12 years old), and 52 babies (under 3 years old).

A total of 4197 people were rescued. Among these, about 1270 were rescued by the rescue units intervened directly under the coordination of MRSC of Livorno.
- 80 people on board the Costa Concordia life rafts were tugged
- 16 people were rescued by helicopter
- 4 people were rescued from the sea

It is estimated that the remaining survivors abandoned the ship on survival crafts (boats and life rafts) and reached the coast autonomously.

(Marine Casualties Investigative Body, 2013)

A total of 32 people did not survive the Costa Concordia disaster. Most of the victims were found trapped inside the ship, some drowned as they tried to swim ashore. Several bodies were found by divers within the vicinity of a two-story restaurant on decks 3 and 4 (The Telegraph, 2012a).

**Table 1 The following chart summarizes the deceased and missing passengers (Marine Casualties Investigative Body, 2013).**

| Number | Age | Gender | Passenger/Crew | Status |
|---|---|---|---|---|
| **1** | 6 | F | Passenger | Deceased |
| **2** | 37 | M | Passenger | Deceased |
| **3** | 79 | F | Passenger | Deceased |
| **4** | 25 | M | Passenger | Deceased |
| **5** | 49 | M | Crew | Deceased |
| **6** | 30 | F | Passenger | Deceased |
| **7** | 30 | M | Crew | Deceased |
| **8** | 67 | M | Passenger | Deceased |
| **9** | 72 | M | Passenger | Deceased |
| **10** | 30 | M | Crew | Deceased |
| **11** | 70 | F | Passenger | Deceased |
| **12** | 69 | M | Passenger | Deceased |
| **13** | 52 | F | Passenger | Deceased |
| **14** | 60 | M | Passenger | Deceased |
| **15** | 70 | F | Passenger | Deceased |
| **16** | 70 | M | Passenger | Deceased |
| **17** | 39 | M | Passenger | Deceased |
| **18** | 23 | F | Passenger | Deceased |
| **19** | 86 | M | Passenger | Deceased |
| **20** | 72 | F | Passenger | Deceased |
| **21** | 62 | M | Passenger | Deceased |
| **22** | 70 | F | Passenger | Deceased |
| **23** | 32 | M | Crew | Missing [1] |

| | | | | |
|---|---|---|---|---|
| **24** | 72 | F | Passenger | Deceased |
| **25** | 71 | F | Passenger | Deceased |
| **26** | 71 | M | Passenger | Deceased |
| **27** | 35 | F | Crew | Missing [1] |
| **28** | 67 | F | Passenger | Deceased |
| **29** | 50 | F | Passenger | Deceased |
| **30** | 49 | F | Passenger | Deceased |
| **31** | 60 | F | Passenger | Deceased |
| **32** | 73 | M | Passenger | Deceased |

Commentary note:

1. On 23rd of May 2013 when the investigative report was released, there were still two bodies known to be missing. On 26th of September 2013 the remains of another body was found, which through DNA analysis was later confirmed to be of a missing Italian female passenger (La Nazione, 2013). In August 2014 while the Costa Concordia ship was moored in the port of Genoa, divers found a human skull and bone fragments on the wreck, which potentially could be of the missing Indian male crewmember (RTÉ, 2014). It is also to be noted that in the official investigation report it is stated that the missing female was a crewmember of age 35, but the body that was recovered in 2013 was identified as a female passenger of age 50. There was however a female Peruvian 25 years old crewmember identified amongst the first recovered bodies (The Telegraph, 2012b).

Figure 8 below illustrates the estimated heeling of the Costa Concordia cruiser from the time of the impact with the rocks.

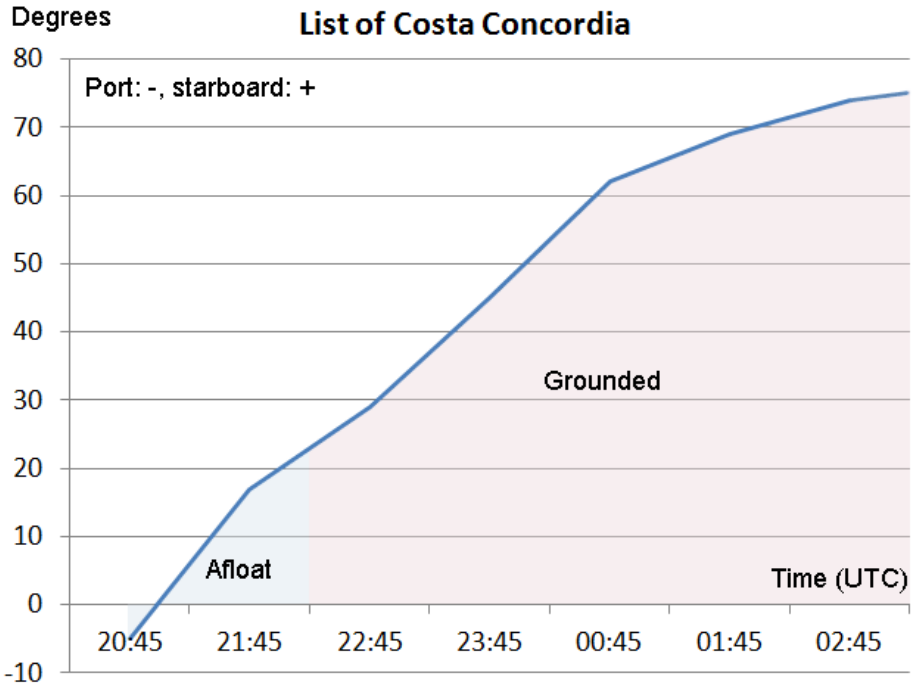


**Figure 8 Note that the time specifications of the x-axis are in UTC – to read the actual local time; 1 hour should be added (image retrieved from Wikimedia Commons, the work is based on the MIT Official Investigation Report by: Soerfm)**

# 6 Discussion

Firstly, it is advisable to note that the case study of this paper has been somewhat delimited in terms of language skills of the author, as the only material analyzed within the thesis has been what was available in English. It is reasonable to expect that the transcripts of witness statements from the Italian court proceedings succeeding the incident would add substantial value to the analysis of human behavior in the Costa Concordia disaster. Furthermore, although a vast amount of material has been analyzed, there is always the possibility that obtainable sources of high significance have remained unseen due to the 'jungle' of information available.

Regarding the accounts of survivors, it is possible that journalists have altered some of the contents, as the media has a tendency of exaggerating certain stories in order to make an article more "newsworthy" or appealing to the readers. This may have had a certain impact on some of the stories told, although the attempt has been to only cite the words of the evacuees. Moreover, another delimitation of the accounts of the evacuees is that they are often quite fragmentary and not entirely easy to place into the time-line of events, as the stories are sometimes a bit jumpy or not always specifically referring to a certain time. Therefore, some qualified guesswork has been undertaken when putting the survivors' statements into the behavior tables.

Essentially many of the uncertainties described above could probably have been eliminated, or at least reduced, had a systematical analysis of the witness statements from the court proceedings been undertaken. In example, there would be no doubts as of whether a certain statement is the words of a journalist, or the actual words of a survivor. Furthermore, there is also a good chance that such an analysis could have provided more quantitative figures as of how many passengers and crew that could relate certain behaviors – compared to this analysis.

It is also noteworthy that the available video recordings may not depict an entirely righteous image of the events as a whole – especially the latter sequence of the evacuation would be interesting to analyze further. As previously suggested, it may also be that the available video recordings only show the situations where people felt comfortable enough to pick up their mobile phones or video-camcorders in order to record the ongoing activities. As the listing of the ship increased it is possible that any filming was deemed "impossible".

With this being said, the discussions will hereafter attempt to address the research questions of the thesis.

In accordance with the hypothesis of Fahy et al. (amongst several others), the term 'panic' has been largely over-used also in the case of the Costa Concordia disaster. Panic was referred to in almost every other article or news report by the media, and a great amount of the disaster victims used the term to explain the behaviors of others and sometimes to describe their own state of fear. Even in the scientific studies the term showed up surprisingly often. However, just as Alexander (2012) pointed out, although there were some indications of panic behavior and chaotic reactions on part of the evacuees, the panic was swiftly mitigated. Hence, it is not likely that panic behavior had a major impact on the evacuation process as a whole. In fact, the only examples of truly irrational behaviors discovered during the work

with this thesis are found in the accounts of Mario Pellegrini, the deputy mayor of Isola del Giglio, who went aboard the cruiser right before midnight. I.e. he describes how he was trying to aid a mother holding a baby to get aboard a lifeboat, but the mother had refused to let to of the child – he had to "struggle to get the baby from her". He further refers to people that would scream and refuse to let go of railings and the interior they were clinging on to, and that they would literally have to be detached by force. Again, panic might not be the appropriate word to describe these behaviors either – supposedly 'fear' is a better explanatory term, even if the behaviors may be seen as somewhat irrational. Nonetheless, it is possible that some people aboard suffered from swift moments of true panic, and panic behavior might have been the cause for some of the people jumping into the water rather than awaiting rescue. On the other hand, jumping into the water could also be the result of decisions made through rational thinking.
In summary the term panic seems to have been used mainly by people trying to explain the competitive behaviors of others and by those trying to describe the overall 'chaotic' atmosphere aboard. When relating to their own emotions or behaviors, people were more likely to use words such as fear or confusion. To give one typical example; "The ship went on a huge, huge lean. Some people started to panic, but I was fine. Even though I was so scared I still didn't really get what was going on."

Based on the video footage, the accounts of survivors, as well as the official investigation and the scientific studies, a few management issues were identified that might have contributed in reducing the effectiveness of the evacuation procedures.

What stands out in particular is the recurrent expression of utter confusion that many refer to. It is clear that the passengers as well as the majority of the crew were not sure of what was happening or how to behave. The distinct grind and boom noise accompanied by the jolting of the ship, shortly followed by the power outage and the incongruous statement from the bridge claiming the situation was under control, was obviously very contradictory. As no one seemed to be sure of how to behave, the reactions of people varied quite a bit; some appeared to freeze, some ran off to investigate, and some started screaming and shouting. The confusion was further enhanced by conflicting orders from the staff, as well as by communication problems due to language barriers etc.

The reaction of the officers in command, operating the bridge – e.g. to minimize the communications with the public – may be a result of the common belief that panic might 'break out' among the passengers if it was announced that the ship had a hull breach. However, as pointed out by Fahy et al. (2009), what people really need in order to make timely decisions is information. Given adequate information, people can improve their awareness of the situation and thus prepare themselves for what is to come next, making them more competent in weighing their options before engaging in appropriate actions. Instead no information was given, which caused an initial state of frustration, anxiety, and suspicion etc. among the passengers.

The other major result of keeping the information from the passengers and crew revealed itself when time came to evacuate. Almost an hour of time was lost that could have been used to assemble the passengers and prepare the launching of

lifeboats. When the general emergency alarm was finally raised – although a great portion of the passengers had already made their way to the muster stations – many were caught somewhat "off guard" and had to rush to collect their lifejackets before continuing to the muster stations. This may have caused additional unnecessary stress and disorder. The delay of the evacuation also allowed the listing to increase further, which in turn made the timeframe to launch the lifeboats a lot narrower. Seemingly affected by the stressful atmosphere, some people began to show signs of competitive behavior, pushing and elbowing their way forward, thus further decreasing the chances of a smooth and orderly disembarkation. As suggested by Drury et al., (2009a, 2009b), competitive behavior is a sign that people sense a low degree of group identification, which – to a certain degree – could be a result of differences in pre-existing norms, values etc. Another explanation for the perceived pushing could also be due to the physical constraints, as more and more people gathered by the lifeboats – even more so as some of the lifeboats were not able to launch.

In the latter sequences of the evacuation, the increased listing of the ship also caused difficulties in walking upright, as well as causing furniture and other interior to fall over –further decreasing the accessibility. All in all, it is fair to suggest that the evacuation could have been much more effective, had the passengers and affected staff been provided with sufficient information at an earlier stage.

Yet another issue that is widely referred to, is the "seeming lack of adequate training" in many of the staff and crewmembers. This may very well be the case, but it is also feasible that their abilities were further affected by the negative stress. As Robinson (2012) stated, it is possible for victims of disasters (including crew) to temporarily forget how to use emergency equipment, or how to maneuver the lifeboats i.e. Even though the staff is trained in handling evacuation procedures, very few have actually experienced a real emergency. Thus, when a disaster finally occurs, even a well-trained person may not always perform in accordance with his or her expectations. However, a well-rehearsed routine will obviously have a greater chance of success compared to one seldom performed, e.g. the chances of staff conducting appropriate behaviors increases with routine by training. It is therefore of uttermost importance to ensure that all staff and crewmembers – with duties assigned in case of an emergency – are sufficiently trained.

As many as 696 passengers had not yet been briefed on the emergency procedures at the time when the accident occurred. Obviously taking part of a muster drill is of great help to the passengers if it comes to an emergency. Having gone through the procedure, even just once, is likely to have positive impact on the evacuees' chances to act in an appropriate manner. For ships on routes where the requirement of muster drills do not apply, the evacuation relies even more on the aid of staff, informative announcements, signage, lighting, etc. The importance of well functioning evacuation procedures and informative evacuation aid can therefore not be enough stressed.

As previously mentioned, language barriers further enhanced the onboard confusion during the disaster. According to RINA (2016), the staff was made up of 38 different nationalities, with a majority that was not able to understand the working language of the ship (Italian), and many that had scarce knowledge of

English (if any). Needless to say, this is bound to cause communication problems in stressed situations, not only between crew and passengers, but also between crew of different nationalities. Higher measures need to be taken to ensure that the crew, at least all involved in the evacuation procedures, are able to communicate with each other as well as with passengers.

The behavior sequence model may be used to explain the chain of consecutive actions that unfolded among passengers and crew after the grounding, e.g., after receiving the first set of cues; namely the grind and boom noise and the jolting of the ship, the interpret-phase was set in motion. Indications of this magnitude are hard to miss and it is therefore legitimate to assume that most people did not ignore these ques. As for the prepare-phase, some of the people seemed relatively satisfied by the following message from the captain, and their consecutive actions were therefore to withdraw and wait for further instructions. Others were more suspicious and began to explore, searching for further ques. Some of the staff instructed passengers to calm down and stay put, while others were instructing to head for the emergency exits. As time passed, the increased listing of the ship provided further indications of something being wrong, eventually resulting in people entering the act-phase; warning others, evacuating, etc.

A number of observations that were made in this analysis of the costa Concordia disaster can also be explained by using the affiliative model. For example, the tendency pointed out by Sime (1983), namely that people separated from their family members tend to respond very quickly to initial indications of threat, was proved to be the case also in the costa Concordia disaster – as discussed by Lazic et al, (2012). Although being reassured that the situation was under control, the interviewed family said they immediately begun searching for their missing daughter. Furthermore, the affiliative model can be used to explain why people in the Costa Concordia disaster formed groups consisting of friends, colleagues, or relatives during the evacuation. The analyzed interviews and observed video-recordings also reveal that people surrounded by their group showed a more "relaxed" response to the initial cues of the accident – i.e. they were somewhat more content with the reassurances received from the staff. This strengthens the part of the theory that says individuals of complete groups may be gaining a deceptive feeling of security for being part of their group.
The affiliative model further suggests that people are more likely to move towards familiar places when they are in a threatening situation, e.g. that they are more inclined to exit the same way they entered a room, rather than using the designated emergency routes (Sime J. , 1985). It has not been possible to verify this part of the theory as the interviews and video-recordings analyzed in this report provides almost no information regarding which egress routes were being used more frequently, respectively less frequent. However, it is possible that if access was gained to the recordings from the ship's internal security cameras (if there were any) it could provide sufficient material to draw any further conclusions.
Lastly, as previously mentioned passenger ships are indeed unfamiliar environments to the majority of the people aboard – the affiliation model might therefore be used as part of the explanation to the peoples' general hesitancy to evacuate.

In the Costa Concordia disaster, both positive and negative aspects of normative and informational social influence were observed. When some of the passengers started moving towards the mustering stations at an early stage, this was a clear signal for some of the others to follow. In this particular context this occurrence may be regarded as a positive aspect of informational social influence, considering it later proved to be a real emergency.
A negative form of normative social behavior could instead be to conform to the behavior of those that listened to the instructions of the staff and returned to their cabins – despite the alarming indications of disaster.
It is hard, if not to say impossible, to distinguish between the two types of social behavior when looking at the video recordings. Nevertheless, whether it depends on informative or normative social influence, it is clear that people were affected by the presence and actions of others. Even though many passengers returned to their cabins, video-recordings show that they kept their cabin doors open so that they would be able to keep an eye at what the other passengers were doing. This further strengthens the theory laid out by Deutsch & Gerard, 1955, whish suggests that people look to other people for information in ambiguous situations and when unsure of how to behave.
Other aspects of the social behavior theory were not possible to confirm, nor deny. The findings of Latané & Darley (1968) and Nilsson and Johansson (2009) suggest that individuals that are alone respond much quicker to indications of a threat compared to individuals that are part of a group. To verify this pattern in the Costa Concordia disaster, one would have to be able to observe the behaviors of people in separate spaces, simultaneously. The public video recordings have been insufficient in this matter, however as previously suggested; if access was gained to the recordings from the ship's internal security cameras – further conclusions may be drawn.

Furthermore, the role-rule model has been proven suitable to explain the roles and associated guidelines that people adopted during the evacuation. For example, the staff with designated duties of aiding the evacuation was more likely to investigate and explore the early signs of the disaster. Passengers witnessed about staff "running their way" right after the ship struck the rock. It is likely that these staff members were headed to search for further clues, or instructions from their superiors. On the other hand, the staff without such duties seemed somewhat more inclined to continue their everyday tasks – video recordings show how kitchen staff and cleaning personnel go back to their regular duties. Recordings and witness statements also suggest that most of the passengers were withdrawing and waiting for further instructions, which also fit well into the theories of the role-rule model. Also, parents ensured the safety of their children and people with natural leadership qualities stepped forward and aided the evacuation – additional examples of actions that strengthen the findings of Canter et al. (1980), Tong & Canter (1985) and Pigott (1989).

The four behavioral models mentioned above are not only valuable when trying to interpret the behaviors of people in a past disaster, they may also be useful at a design stage when trying to predict the behaviors of people.

Some of the identified behaviors that may have contributed in reducing the effectiveness of the evacuation procedures include:

- Confusion – is an indication that people are struggling to find an appropriate behavior. May delay the time it takes for people to act.
- 'Freezing' – leaving people seemingly paralyzed, also an indication of people having difficulties in adopting an appropriate behavior, as explained by Robinson (2012). May complicate the evacuation of the 'frozen' person.
- Competitive behavior – such as pushing, fighting etc. may contribute to disorder, chaotic atmosphere, enhanced risk of injuries, and can essentially affect the evacuation negatively in numerous other ways.
- Insecurity – when a person of charge show signs of insecurity or hesitation, it gives other people reason to believe that he cannot be entirely trusted.

On the contrary to the behaviors mentioned above, there also seemed to be behaviors that had a positive effect on the outcome of the evacuation;

- Skepticism – proved to be a positive trait when questioning the doubtful information from the bridge. It may indeed have made a significant impact on the total assembly time.
- Humor – made people relax a bit and become less anxious.
- Leadership – strong leadership used in the right way can enhance the effectiveness of the evacuation.
- Patience – the good patience of some made up for part of the competitive behavior conducted by others.
- Goodwill and "heroism" – a great amount of people were helping others by giving away lifejackets, helping to carry people that weren't able to walk themselves, or towing people that couldn't swim, etc.

# 7 Conclusions

For the purpose of this thesis paper, the behaviors of evacuees (as reported by media, survivors and official investigations) of the Costa Concordia disaster have been analyzed. The observations have then been compared with theoretical frameworks as an attempt to further enable the understanding of human behavior in the event of a passenger ship disaster. It showed that the behavioral models were useful for the interpretation of a passenger ship evacuation disaster, and it is suggested that they may also be valuable at a design stage when trying to predict the behaviors of people in a maritime disaster.

A number of behavioral factors were found which might have contributed in reducing the effectiveness of the evacuation procedures:

- Confusion
- Freezing (also known as cognitive paralysis)
- Competitive behavior
- Insecurity and hesitation

Several management and operational issues were identified that may have contributed in reducing the effectiveness of the evacuation procedures:

- 696 passengers had not yet been briefed on the ship's safety procedures (as this was scheduled for the following day, 14th of January).
- The public and most of the staff were kept unaware of the severity of the situation, prohibiting them from getting mentally prepared for the evacuation.
- The delay of the assembling and disembarking procedures caused precious time to be lost and led to a narrow time frame for effective launching of lifeboats and rafts.
- Lack of communication between passengers and staff, as well as in between staff, involved language barriers and conflicting orders and led to confusion, misunderstandings and frustration among the passengers.
- Seeming lack of understanding and adequate training among part of the staff caused disbelief in the leadership among passengers.

To improve the safety in passenger ships, it is proposed that extra measures are taken in order to ensure that:

- Passengers are given adequate information; prior to and during an emergency.
- Staff is familiar with the emergency equipment and procedures.
- Staff is able to communicate with each other as well as with passengers.

# 8 Future research

The author would like to take the opportunity to encourage further investigation of the behaviors of evacuees in the Costa Concordia disaster, as well as other maritime disasters, in order to analyze the impact of human behaviors on the evacuation effectiveness.

It is also proposed that future research investigate the use of the behavior sequence model, the affiliative model, the social influence model, and the role-rule model as tools during the design stage of evacuation planning in ships.

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http://www.telegraph.co.uk/news/worldnews/europe/italy/9029866/Costa-Concordia-the-inside-story-of-the-night-of-Friday-January-13.html

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# 10 Appendix – Analyzed video material

**Title:** Inside the Costa Concordia Disaster
**Published by**: ABC News
**Date:** January 20th, 2012
https://www.youtube.com/watch?v=QInuFYRZwPw&list=PLtjiCrCch1UM9YBosMHsvPqwMQ6GgdC5c&index=2

**Title:** Cruise Ship Sinking in Italy; 6 Bodies Found
**Published by**: ABC News
**Date:** January 16th, 2012
https://www.youtube.com/watch?v=_rjy9wek_yg&list=PLtjiCrCch1UM9YBosMHsvPqwMQ6GgdC5c&index=187

**Title:** Inside the Costa Concordia Disaster
**Published by**: ABC News
http://abcnews.go.com/2020/video/inside-costa-concordia-disaster-15408519

**Title:** Raw Video: Panicked Passengers During Evacuation
**Published by**: Associated Press
**Date:** January 15th, 2012:
https://www.youtube.com/watch?v=3Pxw8HYdopA

**Title:** Amateur video from Costa Concordia cruise ship
**Published by**: CBS News
**Date:** January 20th, 2012, 3:02 PM
http://www.cbsnews.com/media/amateur-video-from-costa-concordia-cruise-ship/

**Title:** Costa Concordia passengers warned of "electrical fault"
**Published by**: CBS News
**Date:** January 17th, 2012:
https://www.youtube.com/watch?v=guXCf8SCV1M

**Title:** Audio recording shows ship evacuation delayed
**Published by**: CBS
**Date:** January 19th, 2012:
https://www.youtube.com/watch?v=NJ2-_DudxJ4

**Title:** American family tells how they survived cruise ship disaster
**Published by**: CBS
**Date:** January 16th, 2012
https://www.youtube.com/watch?v=_dGqOJxKBDw&list=PLtjiCrCch1UM9YBosMHsvPqwMQ6GgdC5c&index=80

**Title:** Costa Concordia Cruise Liner wreck : amateur video footage : evacuation : Italy
**Published by**: Creative Videos
**Date:** January 15th, 2012:
https://www.youtube.com/watch?v=eE3QGlAf_7M

**Title:** COSTA CONCORDIA INTERVIEW WITH PASSENGER
**Published by**: cruiseandblog
**Date:** January 17th, 2012
https://www.youtube.com/watch?v=A74NGqFuDjQ

**Title:** Surviving the Sinking of the Costa Concordia
**Published by**: DailyHeraldClips
**Date:** January 16th, 2012
https://www.youtube.com/watch?v=RvUjlwhBsC0

**Title:** Costa Concordia sinking 13.1.2012-The End
**Published by**: David Dor
**Date:** January 21th, 2012
https://www.youtube.com/watch?v=V2GGShZmiXc&list=PLtjiCrCch1UM9YBosMHsvPqwMQ6GgdC5c&index=27

**Title:** Costa Concordia Cruise Sinks During Evacuation
**Published by**: David Saba
**Date:** January 19th, 2012:
https://www.youtube.com/watch?v=4RZlExp7row

**Title:** Costa Concordia Disaster Dining Room
**Published by**: David Saba
**Date:** January 19th, 2012:
https://www.youtube.com/watch?v=KAJW26okcUg

**Title:** Costa Concordia Disaster Dining Room 2
**Published by**: David Saba
**Date:** January 19th, 2012:
https://www.youtube.com/watch?v=gCZFVE-xxmc

**Title:** Costa Concordia Disaster Dining Room 3
**Published by**: David Saba
**Date:** January 19th, 2012:
https://www.youtube.com/watch?v=SSzlvXPy1SU&list=PLtjiCrCch1UM9YBosMHsvPqwMQ6GgdC5c&index=35

**Title:** Costa Concordia Disaster Top Deck After Crash
**Published by**: David Saba
**Date:** January 19th, 2012:
https://www.youtube.com/watch?v=u6Aw7xYE0EA

**Title:** Costa Concordia Disaster Shortly After Collission
**Published by**: David Saba
**Date:** January 19th, 2012:
https://www.youtube.com/watch?v=YzqXRKBz6CA

**Title:** Costa Concordia Disaster - Our Cabin Afterward
**Published by**: David Saba
**Date:** January 19th, 2012:
https://www.youtube.com/watch?v=Pg5L37qOep0

**Title:** Costa Concordia Disaster - Buffet Plates Sliding
**Published by**: David Saba
**Date:** January 19th, 2012
https://www.youtube.com/watch?v=CTtuyDJiMzI

**Title:** Costa Concordia Disaster - About to board liferaft
**Published by**: David Saba
**Date:** January 19th, 2012
https://www.youtube.com/watch?v=TvJ5JIlXbNg

**Title:** Costa Concordia Disaster - Waiting to Evacuate
**Published by**: David Saba
**Date:** January 19th, 2012
https://www.youtube.com/watch?v=velPhOKpwUY

**Title:** Costa Concordia Disaster - Inside the life raft
**Published by**: David Saba
**Date:** January 19th, 2012
https://www.youtube.com/watch?v=vVE_LuUykFs

**Title:** Costa Concordia Disaster - Evacuating in life raft
**Published by**: David Saba
**Date:** January 19th, 2012
https://www.youtube.com/watch?v=8NcSvcMSS1w

**Title:** Costa Concordia Evacuating While Cruise Ship Sinks
**Published by**: David Saba
**Date:** January 19th, 2012
https://www.youtube.com/watch?v=hNFtLap1bUo

**Title:** Costa Concordia Cruise Sinking View From Liferaft
**Published by**: David Saba
**Date:** January 19th, 2012
https://www.youtube.com/watch?v=WV1-UxH_yT4

**Title:** Costa Concordia Cruise Sinks During Evacuation
**Published by**: David Saba
**Date:** January 19th, 2012
https://www.youtube.com/watch?v=4RZlExp7row

**Title:** Costa Concordia sinking right after we got off
**Published by**: David Saba
**Date:** January 19th, 2012
https://www.youtube.com/watch?v=oAhjYvEmdK0

**Title:** Domnica Cermotan telling me I am not allowed to film the Costa Concordia sinking
**Published by**: David Saba
**Date:** January 19th, 2012
https://www.youtube.com/watch?v=Ag-IdQXOIfI

**Title:** Very Shocking video of covered body on strecher being transported after Costa Concordia accident.
**Published by**: David Saba
**Date:** February 1st, 2012
https://www.youtube.com/watch?v=7XDm3nPZH24

**Title:** Les dernières minutes du Costa Concordia. Comme si vous étiez
**Published by**: Darna Television
**Date:** January 25th, 2012:
https://www.youtube.com/watch?v=G5zs2vZo57I

**Title:** Costa Concordia, Captain Schettino audio (English subtitules)
**Published by**: disconube Javier Ibáñez
**Date:** January 17th, 2012
https://www.youtube.com/watch?v=fq-AZz4FBfQ

**Title:** Costa Concordia Latest NEW Video of Evacuation 2012 HD
**Published by**: Kanal von MrPaulKalkbrenner
**Date:** January 31st 2012:
https://www.youtube.com/watch?v=lJV0T3LiGb8

**Title:** Terror At Sea The Sinking Of The Concordia
**Published by**: Maria Fernanda Farias
**Date:** September 21st 2014
https://www.youtube.com/watch?v=5SaaBLhW2p4&list=PLtjiCrCch1UM9YBosMHsvPqwMQ6GgdC5c&index=4

**Title:** sinking of the concordia caught on camera hdtv x264 c4tv p
**Published by**: Matt Antcliff
**Date:** July 20th, 2013
https://www.youtube.com/watch?v=4MtWxnRBVvg&t=10s

**Title:** 5/5 The accident Cruise "Costa Concordia" Shipwrecked in Italy 13 / 01 / 2012
**Published by**: Network 24
**Date:** January 14th, 2012
https://www.youtube.com/watch?v=ZCcoGhsL_CM

**Title:** Costa Concordia: First pics of capsized cruise ship in Italy
**Published by**: ODN
**Date:** January 14th, 2012
https://www.youtube.com/watch?v=Ye1mj7LY2po&list=PLtjiCrCch1UM9YBosMHsvPqwMQ6GgdC5c&index=97

**Title:** Costa Concordia amateur video shows evacuation in progress
**Published by**: ODN
**Date:** January 16th, 2012:
https://www.youtube.com/watch?v=YDw_IWnSzws

**Title:** Costa Concordia: Dramatic footage showing the evacuation
**Published by**: ODN
**Date:** January 19th, 2012:
https://www.youtube.com/watch?v=b99S--7TVSY

**Title:** Costa Concordia: Dramatic night vision footage shows ship evacuation
**Published by**: ODN
**Date:** January 17th, 2012
https://www.youtube.com/watch?v=OBr-T89M85Q

**Title:** Costa Concordia: British passenger describes dramatic rescue
**Published by**: ODN
**Date:** January 15th, 2012
https://www.youtube.com/watch?v=cg5RJYOSqGs&index=17&list=PLFB4BBE3BBE5E7FC2

**Title:** Costa Concordia: The survivors stories from Giglio
**Published by**: ODN
**Date:** January 16th, 2012
https://www.youtube.com/watch?v=-c0mXuDWsao&index=19&list=PLFB4BBE3BBE5E7FC2

**Title:** Russian survivors talk about Costa Concordia disaster
**Published by**: Rianews
**Date:** January 16th, 2012
https://www.youtube.com/watch?v=gbQLzcRA7hA&index=89&list=PLtjiCrCch1UM9YBosMHsvPqwMQ6GgdC5c

**Title:** Amateur video: Shocked Costa Concordia passengers escape sinking liner
**Published by**: RT
**Date:** January 14th, 2012:
https://www.youtube.com/watch?v=mcrBboNWVZ8

**Title:** First video: Luxury Costa Concordia cruise ship runs aground
**Published by**: RT
**Date:** January 14th, 2012
https://www.youtube.com/watch?v=XYwLQDwqDCI

**Title:** Night aerial video of Costa Concordia survivors getting into lifeboats
**Published by**: RT
**Date:** January 17th, 2012
https://www.youtube.com/watch?v=ucxfdfDzTvY

**Title:** Police underwater video inside stricken Costa Concordia
**Published by**: RT
**Date:** January 22nd, 2012
https://www.youtube.com/watch?v=8O5jKC2gISg

**Title:** Costa Concordia accident: Aerial video of dramatic rescue operation
**Published by**: RT
**Date:** January 14th, 2012
https://www.youtube.com/watch?v=EqXkN0gVFbI

**Title:** Cruise ship aground: More aerial views of Costa Concordia
**Published by**: RT
**Date:** January 14th, 2012
https://www.youtube.com/watch?v=daBOOwTpYg8&list=PLtjiCrCch1UM9YBosMHsvPqwMQ6GgdC5c&index=90

**Title:** Costa Costa Concordia cruise ship sinking 2012
**Published by**: steven5149
**Date:** January 19th, 2012
https://www.youtube.com/watch?v=SmQD1wCxMLI&list=PLtjiCrCch1UM9YBosMHsvPqwMQ6GgdC5c&index=66

**Title:** Night vision footage shows Costa Concordia evacuation from the air
**Published by**: The Telegraph
**Date:** January 17th, 2012:
https://www.youtube.com/watch?v=D_FQvW3HKZg

**Title:** Passengers told ship running aground is an 'electrical fault'
**Published by**: The Telegraph
**Date:** January 15th, 2012
https://www.youtube.com/watch?v=D0XsP5-zdhA

**Title:** Cruise disaster: new diver video shows inside Costa Concordia
**Published by**: The Telegraph
**Date:** January 19th, 2012
https://www.youtube.com/watch?v=JT_Ong6iUyg&index=45&list=PLtjiCrCch1UM9YBosMHsvPqwMQ6GgdC5c

**Title:** Video: Amateur video captures cruise ship evacuation panic – Telegraph
**Published by**: The Telegraph
**Date:** 15th, 2012, 9:46AM GMT
http://www.telegraph.co.uk/news/worldnews/europe/italy/9015901/Amateur-video-captures-cruise-ship-evacuation-panic.html

**Title:** Costa Concordia lifeboat escape: new footage
**Published by**: The Telegraph
**Date:** January 16th, 2012, 11:34AM GMT
http://www.telegraph.co.uk/news/worldnews/europe/italy/9017521/Costa-Concordia-lifeboat-escape-new-footage.html

**Title:** Costa Concordia: new video shows panic and disbelief on deck
**Published by**: The Telegraph
**Date:** February 12th, 2012, 1:21PM GMT
http://www.telegraph.co.uk/news/worldnews/europe/italy/9077404/Costa-Concordia-new-video-shows-panic-and-disbelief-on-deck.html

**Title:** Amateur video captures cruise ship evacuation panic
**Published by**: The Telegraph
**Date:** January 15th, 2012, 9:46AM GMT
http://www.telegraph.co.uk/news/worldnews/europe/italy/9015901/Amateur-video-captures-cruise-ship-evacuation-panic.html?fb

**Title:** German passenger films moments after cruise ship runs aground
**Published by**: The Telegraph
**Date:** January 15th, 2012, 5:29PM GMT
http://www.telegraph.co.uk/news/worldnews/europe/italy/9016409/German-passenger-films-moments-after-cruise-ship-runs-aground.html

**Title:** Cruise disaster: Chaos reigned as order came to abandon ship
**Published by**: The Telegraph
**Date:** January14th, 2012, 10:22PM GMT
http://www.telegraph.co.uk/news/worldnews/europe/italy/9015749/Cruise-disaster-Chaos-reigned-as-order-came-to-abandon-ship.html

**Title:** Costa Condordia Cruise Ship disaster: live on board footage evacuation
**Published by**: Werbung | TV | Kampagnen | News
**Date:** January 16th, 2012:
https://www.youtube.com/watch?v=ZBiLRRZRCMw

**Title:** Costa Concordia Cruise Ship disaster: Footage of rescue efforts under water
**Published by**: Werbung | TV | Kampagnen | News
**Date:** January 16th, 2012
https://www.youtube.com/watch?v=b92MpEZRIUQ&list=PLtjiCrCch1UM9YBosMHsvPqwMQ6GgdC5c&index=109