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Investigating Abandonment Errors in Cruise/Passenger Ships: Researching the Reasons Leading to Life-Losses During an Evacuation

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ABSTRACT: Over the course of time and under the auspices of the International Maritime Organization (IMO), safety at sea has significantly increased. Numerous regulations have been adopted in an effort to increase safety standards onboard ships and reduce the probability of accidents. Unfortunately, abandonment procedures still remain at large inefficient. A very indicative example is provided by the evacuation of Costa Concordia, which lasted more than 6 hours, although the International Convention for the Safety of Life at Sea (SOLAS) dictates this type of operation should not exceed 30 minutes. This research effort aims to provide a clear understanding to the causes behind the inefficiencies and flaws existing in the current evacuation procedures. By deploying a qualitative method, causes behind the accidents and how these can affect the abandonment process will be explored; contributions of the human element and how the psychological/behavioral attributes of people can affect the outcome of an evacuation will be included. Finally, the design of passenger/cruise ships will be discussed in an attempt to identify possible areas of improvement.

1 INTRODUCTION

"Evacuation" describes an emergency response action that is implemented during a situation associated with immediate peril for the lives of all people onboard a vessel (crew and passengers). During these crucial moments, the main goal is to muster everybody swiftly and efficiently; unfortunately, any inability to take effective actions/decisions can lead to serious delays in abandoning the vessel. A failure in timely evacuation of crew and passengers can be proven fatal, since the available time (after the order of abandonment) is of utmost importance. During this short time frame, which as per the guidelines of SOLAS shall not exceed 30 minutes, the passengers and crew shall be gathered to the Muster Stations, boarded to the evacuation means (lifeboats, life-rafts) and depart from the vessel in distress. Although, this three-step ship evacuation process seems relatively simple, over the years, a significant number of life-losses have occurred. The reasons behind the casualties vary widely between incidents, but in most cases, they can be attributed to human errors, design and layout failures and of course the variable circumstances under which the abandonment was conducted, since the cause of abandonment is decisive for the overall evacuation outcome.

IMO, by taking into consideration the need of the market to produce ships of considerable size/ carrying capacity and recognizing the complexity of the design for Cruise or Passenger vessels, over the years has issued circulars which prescribe certain calculating formulas that shall be adopted by naval architects during the ship design phase. These formulas are used to measure the efficiency of the ship design in case of an emergency evacuation by recreating an evacuation scenario and measuring if the desired evacuation times are fulfilled. The objective behind this is not only finding the best, but also the shortest, evacuation routes and identifying the approximate required time of evacuating all people onboard. Furthermore, apart from the structural and design features of a vessel, a large part of the outcome of a ship's abandonment is directly linked to the human element. From crew to passengers, the impact of people is of significant importance in any social environment, especially when they are found under threat and their reactions in the face of danger diversifies greatly. Therefore, the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) and SOLAS have established safety and training procedures that shall be followed (both by crew and passengers) before and after their embarkation on passenger ships. These safety procedures aim to familiarize the passengers with the processes and steps that shall be followed during an emergency situation onboard a ship, with the ultimate goal being to avoid delays that can lead to fatal results.

This paper attempts to approach the topic of ship evacuation holistically by initially presenting the causes and accidents that can lead to the need of abandonment during a ship's journey. Furthermore, it presents the ship design methods that have been developed in order to ease the evacuation and identifies the shortcomings that still exist in these methods and can inhibit the effectiveness of abandonment procedures. Finally, the following research discusses the complexity of human nature when it is faced with an unprecedented danger and how human behaviors can detrimentally influence a passenger ship's evacuation procedure.

2 METHODOLOGY

This study was conducted by utilizing a semi-systematic literature review and particular attention was paid to the current training standards and procedures (as required by the STCW), which are followed during the certification process for every crewmember and Officer. Moreover, this literature review process included various peer-reviewed articles in the open literature, attempting to provide a clear insight to the mental and psychological state that the crew/passengers experience during an evacuation. As it has been observed during a ship's abandonment, people can exhibit various irrational behaviors, a fact that can negatively impact the procedures by causing further confusion and delays. Additionally, the research covered the situational constraints that can furtherly hinder the evacuation as they are unpredictable and inconsistent, e.g., the weather conditions, speed of escalation of the damages the vessel is enduring, etc. Relevant grey literature documents (special reports and/or International Codes/Regulations) were used, often in conjunction with peer-review literature, aiming to get supporting material and objective opinions around accidents that influenced largely the course of the modern shipping industry and to showcase the changes and amendments in International Regulations.

3 DISCUSSION

3.1 *Ship Design*

The advancement of the modern naval architecture during the last thirty years has led to a trend of building larger passenger vessels (cruise ships/ferries), capable of accommodating thousands of passengers [1], with the largest cruise ship today being capable of transporting approximately seven thousand passengers. As the world is progressively recovering from the devastating effects of the COVID-19 pandemic, the Institute of Shipping Economics and Logistics, reports that the Cruise Lines International Association (CLIA) [2] expects that by the end of 2023 the passenger numbers will surpass the pre-COVID-19 levels, reaching an increase of 12% in 2024, compared to 2019. Moreover, it shall be mentioned that the passenger ship industry contributes significantly to the global economy, generating a revenue surpassing 154 billion USD in 2019, as reported by CLIA. Therefore, in an ever-growing passenger ship market, the design/durability of the ship is of ultimate importance in order to achieve the ultimate level of safety for passengers and to ensure the profitability of the cruise and ferry market. Nevertheless, it can be understood that a voyage at sea increases the safety risk for each individual onboard. As per the report submitted by Allianz [3] in 2022, between the years 2011-2021, 72 passenger ships were lost. In addition, according to Table 1, approximately 2600 people lost their lives in various disasters between 2011-2016 [4].

Table 1. Passenger Ship Accidents and fatalities from 2011 – 2016

Ship Name	Type	Fatalities	Year
MV Spice Islander	Passenger Ferry	1,529	2011
Costa Concordia	Cruise Ship	32	2012
MV ST Thomas Aquinas	Passenger Ferry	120	2013
MV Sewol	Passenger Ferry	304	2014
Dongfang Zhi Xing	Cruise Ship	442	2015
Aung Soe Moe Kyaw 2	Passenger Ferry	99	2016
Total		2,526	

Source: Created by the authors, based on data available in the paper: Determinants, methods, and solutions of evacuation models for passenger ships: systematic literature review by Arshad et al, 2022.

Especially after the incident of M/V Estonia, that resulted in the loss of life for 851 people, the IMO has taken decisive measures in order to reinforce the onboard safety of vessels [5], starting from establishing effective measures and standard quality assurance procedures from the design phase of a vessel. Part of these procedures refer to the capability of a vessel in maintaining stability after excessive water intake or constructional fire protection, adequacy of essential ship systems and ultimately evacuation arrangements as the final safety measure, if everything fails [6]. Over the years, regulations concerning the optimization of ship design have been developed and adopted by SOLAS and a number of Maritime Safety Committee (MSC) Circulars have been also introduced, aiming to set clearer directions towards the design of the "evacuation ability" of a passenger ship. More precisely, SOLAS in Chapter II-1/2 [7], dictates the structure and stability requirements that a vessel shall be equipped with, in order to accommodate high-safety levels under any unanticipated incident. Furthermore, the MSC/ Circ. 1033 that came into effect in 2002 describes the methods of evacuation analysis that shall be performed during the design phase of a vessel or the modification of an existing ship in service, in order to be determined if the abandonment can be performed in the established time frame (30 minutes as per SOLAS Ch. III/ Reg. 21.1.4) [7].

As per the Guidelines offered by MSC/ Circ. 1033, there are two distinct methods that can be utilized:
1. A simplified evacuation analysis; and/or
2. An advanced evacuation analysis

The simplified method analysis is based on the "fluid-dynamic principle", where the corridors and stairs of the vessel's interior are considered as the tubes, while the passengers are the fluid "which flows inside them". For the accurate analysis execution, a specialized procedure is followed, based on algorithms and calculations that are defined in the Circular. On the other hand, the advanced evacuation analysis, views the passengers individually with distinct features; aiming to take into consideration people of all ages and physical well-being, that consequently affects largely their walking speed and their ability to move rapidly through adverse conditions. The calculation of the evacuation times is based on virtual-reality software, that utilize algorithms and methods prescribed in the Circular [8]. Based on these guidelines, the desired evacuation time (30 minutes as per SOLAS Ch. III/ Reg. 21.1.4) [7] is set as the objective function, consequently the available evacuation time is a natural constraint. During the calculations, if the computed evacuation time exceeds the available time, then the evacuation plan shall be revised. In case that even after the revisions, a solution satisfying the given limitations cannot be found, then modifications should be introduced to the current layout of the escape routes. When finally, the design of the evacuation routes and the evacuation plan are corresponding to the prescribed requirements, the design process can move to the next step [9,1].

In both cases, the adopted algorithms allow for the calculation on whether or not the laid design is corresponding to the SOLAS requirements for the evacuation of passenger ships. Furthermore, the main objective of the methods is to avoid possible jams towards the emergency exits and to reduce the evacuation time as much as possible, aiming to avoid possible casualties or the condition of the abandoning vessel to go out of control [1]. On 2016 the MSC.1/Circ. 1533 [10] was issued by the IMO, in order to renew and revise the existing guidelines as set in Circular 1033 and made mandatory the determination of the evacuation time during the design phase of every new passenger ship (the analysis was also recommended for existing passenger ships in service), using the aforementioned methods.

Nevertheless, based on the opinion of various scholars, the evacuation analysis methods that have been adopted by the IMO, although they address issues concerning the layout of the main escape routes and passenger demographics, fail to take into consideration the problems evoking during real life-threatening conditions [11]. Since, the nature of each incident is unique, every detail can impact the evacuation process widely. For example, the heel and/or trim of the ship (due to water intake), can lead to halting the movement of the evacuees due to inclined escape routes, and additionally large inclinations (more than 20 degrees) can severely affect the deploying ability of the evacuation systems, an event that observed during the M/V Estonia incident in 1994 [12,13]. Moreover, the behavioral patterns displayed by the passengers can widely vary between total immobility to excessive overreactions [13], thus affecting the progress of the abandonment procedure. Another important unweighted factor is the reactions of the crew that are directly linked to their personal familiarity with the evacuation procedures and their ability to cope with stressful situations.

Taking into consideration those issues, considerable effort has been made into developing refined software models capable of simulating analogous environments during the design phase of a ship. In that way the designer would be able to retrieve a full spectrum of possible scenarios, hence enabling the construction of a safer vessel. Over the years an extensive amount of digital modeling tools has been created with different and large capabilities, indicatively but not limited to these are the following:
1. Maritime Exodus: Incorporates the prescribed evacuation analysis methods with trial data of the behavior of passengers under conditions of trim and list.
2. VR Velos: Provides a simulation tool that is based on the recreation of abandonment conditions by utilizing virtual reality.
3. AENEAS: A fast performing simulation tool that can be utilized in handling large numbers of passengers.
4. IMEX: An evacuation model that integrates human behavior modeling with dynamics.
5. BYPASS: A simple cellular-automation model.

These simulation platforms (without the aforementioned list being exhaustive) enclose vastly developed technological solutions, aiming to achieve close proximity to real-life emergency conditions. A number of them can even construct and employ the use of "avatars", capable of having roles as passengers, crew-members, family-groups (as the dynamic of people related with each other differs, compared to individuals). Furthermore, among others, they can recreate interchangeable weather and stability conditions that are experienced during emergency events happening in open sea conditions. The majority of the available programs are capable of creating evacuation analyses by using both of the proposed evacuation analysis methods (simplified and advanced) as indicated by the Circulars, and ultimately to provide a comparison between them [11].

However, literature shows that even though a significant progress has been made towards recreating evacuation simulation that corresponds to reality conditions, there are still serious shortcomings that might impede an abandonment procedure. By dividing the evacuation factors into configuration, environment, procedure and human behavior and considering that in order to take a realistic evacuation overview, all of them should be equally classified; it is observed that due to computational ability limitations, technical difficulties, and application characteristics, the systems do not take all the factors in equal consideration [14]. Moreover, there are no digital platforms capable of recreating "actual" human behavior. Most digital programs used during ship design are able to represent only basic human behavioral norms, such as evacuation path selection, group behavior, walking speed, etc. However, due to the complexity of human nature, especially during mental and psychological challenges, the effects of panic, fatigue, and other unexpected behaviors, cannot be quantified.

3.2 *Human Element*

The topic of ship evacuation incorporates a quite wide research spectrum, which encompasses various different aspects; among them are the impact of the event(s) leading to the need of evacuation, the condition and structure of the impaired vessel, the design of the vessel, the evacuation means. Unfortunately, human psychology and behavior regarding the topic of ship abandonment occupies only a small part of the existing research [15]. Human behavior can greatly affect the outcome of an evacuation, as individuals are prone to displaying a multitude of attitudes influenced by different factors, such as age, physical condition, familiarity with the space, nature of the disaster, whether they are travelling alone or with friends/ family, etc. It can be understood that a delay in passenger mustering can lead to delays that ultimately can lead to major life-losses. As per [16] the abandonment process can be divided in three main stages:

– Pre-movement phase: It initiates after an alarm has been activated. During this period, the people are attempting to collect information about the unveiling situation from passengers and crew around them, but they are also observing the behaviors and actions of the people surrounding them. In several cases this period can be quite long-lasting, as humans tend to ignore the first emergency and alarm signs and continue their routine. This behavior can be directly associated with denial. It has been observed that people fail to accept that their life and safety is in danger and on the contrary they try to connect the ongoing warnings to past false alarms. These can be linked to the fact that people generally react and perform pre-planned behaviors and norms that they use in their daily life activities. Consequently, when a novel situation appears there is an immediate need of generating a new behavioral pattern that will help them correspond effectively. This pressuring needs in the majority of cases might lead to freezing and inability to act. It shall be also taken into consideration that people are social creatures and are directly influenced and affected by the behavior of the people in their close vicinity. It can be understood therefore, that the individual reaction to an emergency is directly linked to "mass reaction".
– Motion Process: This phase commences after the passengers (and crew) onboard have come to the realization that there is an imminent threat to their life and they have to take action. It is characterized by wayfinding decisions and activities that the passengers shall follow during the limited given time. During this phase the people shall select the most efficient path, from their initial unsafe position to a safer one (e.g., life-boat, life-raft, muster station). Furthermore, people are asked to follow the crew's instructions and guidance, in order to avoid congestion and formation of crowds. This can be considered the most demanding, important and crucial stage of the whole evacuation procedure, as the success of the procedure is dependent on various factors that shall be taken equally into consideration, such as the familiarity of the passengers with the evacuation procedures and with the vessel, the guidance of the crew towards the passengers that is directly linked to their leadership and management abilities and also on the quality of training that has been received by them. Since it is in human nature to follow and trust figures with authority, it can be understood that wrongful instructions and guidance can be proven fatal.
– Achievement of the safe place: This is considered the last phase during a ship's emergency evacuation and it involves the embarkation process of the passengers and crew to the evacuation vessel and in continuation to that the launch of the safety means.

Having explained the main stages of an evacuation procedure, aiming to showcase the processes that an individual is facing during an emergency condition, a more deep and thorough examination of the human behaviors is required in order to examine what hides behind the delays that can ultimately lead to casualties. It shall be mentioned that no simulation can provide robust results around the behavioral and psychological patterns that individuals experience during real-life emergencies [17]. This can be clearly attributed to the fact that during evacuation trials the people are aware of the fact that their lives are not in danger and they are just a part of a statistical research, thus they act rationally. In contrast, during real-life emergencies that decisions tend to be seriously influenced by their surroundings (behaviors of others, unveiling conditions, etc.), the people tend to display various behavioral patterns and emotions that can delay the outcome of the evacuation. These behaviors are often characterized as "panic".

Image 1. Impulsive reactions of people during a cruise ship's evacuation, Source: The Royal Institution of Naval Architects

Many debates between scholars can be found on whether or not panic occurs between the individuals after the order of evacuation has been given. Keating [18] supports that in order for an attitude to be classified as "panic behavior" it shall include four essential elements: firstly, there is a willingness-hope to escape through routes (or either means) that are either inaccessible or insufficient for granting to the individual a safe passage. Secondly, the behavior exhibited is contagious between the concentration of people and is usually initiated and transmittable to the crowd by an individual who has a leadership role. Thirdly, each person displays aggressiveness towards other people in the close vicinity and is concerned solely for his personal safety, while being totally indifferent for the well-being of the others. Finally, the mass is unable to exhibit rational and logical responses to the surrounding circumstances. Often, people are not aware of the surrounding dangers and conditions and resort to actions that are dangerous to themselves, such as attempting using the elevator instead of stairs during the abandonment. Ockerby [19], seemingly agrees to the aforementioned by supporting that "Panic is associated with non-coping behavior", and he adds that regularly during emergencies panic is confused with emotional and mental stress, but nevertheless the victims are able to maintain their sanity and respond effectively to the occurring perils, while maintaining their concern about the others. That was observed also during the sinking of M/S Estonia, that people in many cases even though they were facing extremely dangerous conditions, were showing solidarity to others and they were trying to assist to the extent they could. It can be understood therefore that panic is not in every case the cause behind the evacuation delays that ultimately leads to fatalities.

Harbst and Madsen [20] believe that delays might occur due to the fact that passengers do not pay the required attention during the drills performed at the initial stages of a voyage. People tend to subconsciously accept the risk of each action they take, and unfortunately, they are unprepared to act when emergency calls. This is mirrored usually in every new environment individuals encounter. How many people really study the emergency plan and exits of a hotel or ship they embark on? How many people really pay attention to the safety instructions before a plane's takeoff [20]? It is understandable therefore that since a mistaken safety perception has been formed inside them, the time needed to act effectively in an emergency scenario will be increased and also incorrect behaviors and actions might be anticipated [15]. This phenomenon in combination with the pre-movement phase of the evacuation process, where people are experiencing denial about the ongoing reality and thus, they are unable to respond effectively to the new situation as initially they refuse to believe that their life is under threat, can increase even further the response time and consequently affect furtherly the progress of the evacuation.

Another common evacuation mistake is the "delayed alarm". It has been observed in numerous cases, that the Master and crew in charge might postpone raising the alarm until it is absolutely necessary. This attitude is based on the assumption that a possible alarm will create "panic" from a really early stage, where it is not certain if the condition of the ship will demand the necessity of evacuation [19]. The concept of alarm delay was also used at M/S Estonia with disastrous results for the passengers, as a lot of crucial time was lost. The US National Transportation Safety Board supports that a delay in sounding the general alarm and directing to the muster stations the passengers and crew, can be critical to their survival and well-being and supports that "passengers shall be aware of the real conditions from an early stage". Moreover, since the speed of escalation of the damage that the ship has endured is unknown, a late alarm might be proven fatal [21]. In other words, leaving passengers in ignorance can be classified as a gamble that can have catastrophic consequences.

An additional highly influential factor towards the outcome of an evacuation, is the crew and their capacity to act in emergencies. As dictated by the STCW Convention [22] every crew member eligible to work onboard a vessel, is obliged to undergo Basic Training and familiarization (STCW Reg. VI/1). In combination to that, SOLAS Chapter 3, Reg. 19.3 [7] mandates that at least one abandon-ship drill shall be performed every month for merchant vessels and at least once-a-week for passenger vessels, to ensure the crew's preparedness for emergency situations. Furthermore, a drill within 24 hours since the departure of the vessel from a port shall take place in case that a number exceeding the 25% of the crew has not participated in a drill during the past month, or is new. Despite the existence of a regulatory framework, research suggests that in large cruise/ passenger vessels which employ a considerable number of people, it is common for inconsistencies to exist between the training that the crew receives; as the higher ranks tend to receive more training days compared to the lower positions [23].

Additionally, Szcześniak [24] claims that in several cases the crew does not put adequate effort and attention towards the correct and effective execution of onboard drills. Drills are treated by many crew members as a boring obligation that has to be fulfilled during their spare time, in order to comply with the International & Company requirements. As these individuals are overconfident with their abilities (this is most commonly observed between older crew-members), they tend to limit their responses to the minimum. Consequently, when a real-life threat appears it is doubtful if they will be able to respond effectively on time. Other scholars support that the maritime community lacks an effective and inclusive safety culture onboard ships, capable of allowing the creation of a safe place that will better accommodate the exchange of ideas and perceptions equally between all crew members [25]. It is a common phenomenon for lower crew ranks hesitating to express their questions or opinions during drills or safety meetings, as they are afraid of being mocked or disregarded [26]; this can lead to severe consequences for the general human survival during a shipboard emergency. Overall, it can be said that crew's training plays a key role in the outcome of an abandonment. People have the tendency to obey and follow people with authority or expect guidance from them [16]; therefore, it can be understood that an insufficient and incapable crew can have a lethal impact on the lives of passengers.

3.3 *Causes behind Accidents:*

Many factors and events happening during a disaster can influence directly the survivability of crew and passengers onboard a vessel. The extent of the ship's damage, sea conditions, water depth, proximity to the land, prevailing season, weather, time during the day, are only few of the factors that can have a decisive imprint in the outcome of a ship's abandonment. A fairly good example to this is the comparison between Titanic and Costa Concordia, two state of the art (for their time) cruise/passenger vessels that both sustained structural damages and excessive flooding. The main difference here is that Titanic sank in the deep-freezing waters of the North Atlantic Ocean, around 400 miles from the closest shore; while Costa Concordia ran aground in the coast of Giglio Island during the early days of 2012. Even though the accident of Costa Concordia happened at a distance of approximately 300 meters from the land, the evacuation lasted more than 6 hours and 32 people lost their lives. It can be assumed that if the circumstances during the accident were different, the casualties would have been much higher [24]. Although the conditions under which a disaster occurs play an important role towards the outcome of the evacuation, the success and effectiveness of an evacuation procedure in most cases is closely linked to the accident that has preceded. When it comes to an accident there are several possible occurrences onboard a vessel that can lead to the need of abandoning a ship. Based on a study published by Cardiff University in 2016 [28], which examined 693 accident cases based on accidents investigation reports ranging from 2002 to 2016 (Table 2), there are 5 main categories that maritime accidents can be distributed: collision (including close quarters and contact), grounding, fire (and explosion), lifeboat, other (poor judgment, technical failure, poor design, etc.).

Table 2. Marine Accident Cases from 2002 – 2016

Types of Accidents	Frequency	Percentage
Collision, Close Quarters & Contact	248	35.8
Other	238	34.2
Grounding	118	17.0
Fire and Explosion	66	9.8
Lifeboat	23	3.3
Total	693	100

Source: Created by the authors, based on data available in the paper: The causes of maritime accidents in the period 2002-2016 by Cardiff University

As it can be understood, the most common accident type is collision. In addition to that (based on the given study) it shall be mentioned that the most common cause of collision or close quarter situation is inadequate lookout. This can be closely linked to the misuse of the available technology or the overreliance on it. It is supported as well that the inadequate communication between crew members is another contributing cause that can lead to a collision. Furthermore, grounding is another major accident category. It has been supported that inadequate communication between personnel, wrong chart use and insufficient manning levels are the primal causes behind grounding. It is also highlighted that a grounding can increase mortalities considerably. Fire and explosion accidents can be mainly attributed to inadequate risk management and poor emergency response after the occurrence of the event. It was additionally found that insufficient maintenance of equipment onboard can contribute significantly in the commencement of a fire or explosion. It is important to mention that as per a report published by the U.S. National Research Council in 1991, the casualties and deaths following a fire accident can be on average 132% higher than from incidents where no fire or explosions have occurred. This is associated with the fact that these devastating events due to their nature and the rapid progression of fires in the majority of cases, leave small time windows for the evacuation of passengers and crew. As "Other Accidents" are classified a wide variety of incidents that can have catastrophic consequences on the vessel and its occupants. The causes behind this category of accidents can be anthropogenic or external factors:

- Anthropogenic Factors: Rule Violation, Alcohol, Unsafe Speed, Overloading, Distraction, Fatigue, etc.
- External Factors: Weather, Technical failure, Visibility, Traffic, Sea Conditions.

As it can be understood these factors vary widely from case to case and are responsible for around one third of the occurring accidents. Furthermore, it shall be highlighted that the surrounding circumstances an accident occurs can have a decisive role towards the survivability of people. It has been observed that mortalities during night-time accidents are elevated by approximately 17% [20]. This can be affiliated with the fact that the evacuation time during darkness periods lasts longer, mainly because the majority of crew and passengers are asleep or resting, compared to daytime where the majority of people are awake or working. All in all, it can be understood that the accident leading to the need of evacuation, together with the surrounding circumstances can greatly influence the chances of the survivability of crew and passengers before and during the abandonment process. Based on the explanation of the aforementioned accident types, that even though those disastrous incidents can differ widely between them and can occur under different circumstances and environments; the common denominator between them in the majority of cases is once more the human element.

4 CONCLUSION

This paper analyzed the various factors that can have a detrimental effect on the lives of crew and passengers during an event of emergency evacuation. As evacuation is a multidimensional topic and process that encompasses a variety of elements, there was a need of conducting diverse research that would take into consideration different influential factors during an abandonment scenario, starting from the ship's design phase and the methods that are implemented to achieve maximum safety and survival chances during an emergency scenario. In continuation to above, the nature of the accident and the influence that can have in relation to the efficacy of the evacuation process and the survivability of the people onboard was discussed. Finally, human attributes and their related effects during the event of an evacuation were discussed.

More precisely, the paper initially presented the progress that has occurred in the cruise/passenger industry during the last decades and the need of the industry of producing bigger vessels, able to accommodate large numbers of passengers and crew. Furthermore, the paper discussed the introduction of requirements and design analysis methods from the IMO, which shall be adopted by the naval architects during the ship design phase in order to examine whether or not the design of the ship is determined efficiently for the passenger and crew movement during an evacuation. Additionally, the paper analyzed the different evacuation analysis methods proposed by the IMO and showcased different digital simulation programs that have been developed over the years, while also displaying the shortcomings and limitations of the existing technology in the design processes that can have adverse effects during an evacuation.

Secondly, the paper discussed the connection between a maritime accident and the outcome of the evacuation. More specifically, a number of approximately 700 maritime accidents was analyzed and the causes behind the accidents were distributed in 5 different categories. Subsequently each category was analyzed in combination with additional research papers, in order to extract a safe conclusion around the effects of each accident in the abandonment aftermath. Moreover, the paper elaborated furtherly on the significance of the surrounding circumstances at the time of the accident and on their catalytic influence in life-threatening conditions.

Finally, the influence of the human element during an abandonment scenario was analyzed. Because of the complexity of human psychology and reactions in the face of danger, there are many different and opposing opinions around human behavior during moments of peril that can have harmful effects on humans and especially during an evacuation event. Furthermore, several human behaviors that are displayed during moments of danger were discussed, in an effort to shed light behind the evacuation delays and fatalities. At last, common practices and perceptions of the crew during emergency circumstances were explained and common incorrect attitudes of crew and passengers towards drills and training were highlighted.

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