Evacuation of ships: Discovering the mishaps behind the casualties

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ABSTRACT
Safety of crew and passengers has always been a very critical issue for the shipping industry. At the beginning of the previous century, the tragic event of RMS Titanic sinking, can be considered as the triggering event for the introduction of the main regulatory intervention by the International Maritime Organization (IMO) in terms of safety: The International Convention for the Safety of Life at Sea (SOLAS). Since that point in time, with the aim to improve the procedures followed during a ship evacuation situation, numerous regulations have been adopted. Unfortunately, especially in relation to large passenger vessels and cruise ships, abandonment procedures remain today largely inefficient; in numerous occasions, an abandon ship situation has resulted into fatalities that were somehow considered avoidable, with the case of Costa Concordia standing out as an example. This paper is attempting to identify the main reasons and conditions behind the mishaps during the evacuation of modern passenger/cruise vessels. The purpose is to provide an understanding and shed light to the inefficiencies existing in the currently followed procedures. Furthermore, the psychological impact that is caused to passengers and crew in chaotic and life-threatening conditions, as the aforementioned situation, is discussed.

Introduction
The sinking of RMS Titanic in 1912 and the tragic loss of more than 1,500 lives had a profound effect as it brought to the forefront of the maritime industry’s attention several important issues concerning the safety of crew, passengers and property. In 1914, an International Conference examining the wider topic of safety of life at sea was held, in response to that tragic disaster and with the aim to address existing problems concerning life-saving appliances, radio communications, ice patrolling, and the safety of navigation; thus, the introduction International Convention on Safety of Life at Sea (SOLAS) was facilitated several years later (Dalaklis, 2017). Until that point of time, there were no international laws, regulations, or conventions addressing safety-related issues on vessels such as the number of lifeboats carried onboard, or the necessity of responding to distress signals received by vessels in the surrounding area.

For British flagged merchant vessels, such as the Titanic, the British Board of Trade was responsible for shaping and putting into effect regulations concerning the safety and well-being of crew and passengers, as well as other norms of the operation of each vessel (Merchant Shipping Act, 1894). Of particular interest is the fact that at that time, the number of lifeboats carried by a ship was not determined based on the capacity of people it could accommodate, but was calculated based on the Gross Tonnage (GRT) figure of each vessel. Titanic had a 46,328 GRT and therefore was obliged by the existing regulations to carry at least 16 lifeboats; although that vessel was finally equipped with 20 lifeboats – having a total bearing capacity of 1,178 persons - their available capacity number constituted less than one-third of the total approved carrying capacity of the vessel, which was 3,547 persons (Hutchings & De Kerbrech, 2011). The disastrous sinking of Titanic and the massive number of life-losses it caused was able to change the erroneous perception of “unsinkable” vessels and triggered considerable improvements in terms of ship design and related equipment.

In relation to the topic of Life Saving Appliances (LSA), another very influential disaster – which truly shocked the world and shifted the attention of the maritime industry once more to the safety procedures/measures taken during ship’s evacuation – was the disastrous sinking of the MS Estonia; it is considered one of the deadliest maritime tragedies of the 20th century. The MS Estonia left Tallinn on the 27th of September 1994, while carrying 989 persons, heading to Stockholm. The weather conditions, while the vessel was underway deteriorated rapidly, with strong winds (29–39 knots) and high waves (4–6 meters). Around 01:00 the high waves opened and finally broke off the bow visor, thus allowing the sea to storm inside the vessel and cause a heavy list. Estonia sank after approximately 50 min, taking with her 852 lives either
trapped inside her or dying of hypothermia in the cold Baltic waters. After the accident the governments of Sweden, Finland and Estonia formed the Joint Accident Investigation Commission (JAIC), in order to shed light and acquire answers on the sequence of the events before, during, and after the sinking (JAIC Final Report, 1997).

The JAIC after examining the wreck, the recorded evidence from the Voyage Data Recorder (VDR) and the interviews of the survivors published its final report on the December of 1997. The report was able to give a better understanding on the facts that led to the high number of casualties. According to the findings, the order of the evacuation was delayed as the first known MAYDAY transmission, together with the lifeboat alarm from the vessel occurred at 0122 hrs, when the list of the vessel was already listing more than 40 degrees, without providing any further general information to the passengers prior to that. This gave a very small time window for crew and passengers to gather at the designated Muster Stations and prepare for evacuation. Furthermore, the inability of the crew to launch any of the 10 lifeboats of the vessel can be equally distributed to the severe list of the vessel and further to the lack of time for the crew to be organized and to respond to their designated duties and positions. Since it was impossible for the lifeboats to be used, crew and passengers started preparing the life rafts for launch, but many of them were blown away by the strong wind. Taking into consideration that the list at around 0135 was reported to be about 80 degrees, it is possible to understand the rapid sequence of the unfolding events.

Moreover, the JAIC report indicated that there were inconsistencies around the reaction several crew members had when faced with the reality of the evacuation (and the prospect of death). The delay of the announcement of the alarm, together with the absence of further guidance and information from the Bridge side, can be considered as the first major mishaps of the evacuation. Furthermore, the JAIC identified as one very important contributory factor the overall reaction of the passengers (JAIC Final Report, 1997). It is clear that panic had taken over the vast majority of the people, thus leading them to exhibit irrational behavior patterns, such as behaving without control by screaming, moaning, and moving not in a purposeful way. Many of them were just standing shocked and paralyzed or were trying to hold themselves on handrails without moving or making any effort to reach the evacuation deck, thus creating physical obstacles to others. The greater portion of the survivors are considered to be individuals that came into a quick realization of the occurring events and made strong personal efforts to save first theirselves and then help others.

In the aftermath of the sinking of MS Estonia, several SOLAS amendments came into force; they were mainly related to the stability and structural features of a vessel, e.g., bow doors, collision bulkheads, flooded compartments, escape routes. At the same time, improvements and changes came into the fields of LSA, operational limits, working language and conditions of ship’s operation. Since this paper is focused on vessels’ evacuation, special emphasis will be made to the changes that were introduced to this specific domain. Amendments were made in order to include new regulations around the escape routes on RO-RO passenger ships, aiming to enhance the safe movement of people during emergency situations (SOLAS Chapter II-2, Regulation 28–1). Furthermore, the installation of public address systems on all passenger vessels became mandatory (SOLAS Chapter III, Regulation 6.5) and more importantly, more stringent requirements in relation to life rafts were introduced. Last, but not least, based on the new regulations every passenger carrier shall be equipped with at least one rescue boat and means for transporting the survivors from the rescue-vehicle to the ship with safety (SOLAS Chapter III, Regulation 24–1). The sinking of MS Estonia provides a particular case of accident, since it combines a broad range of unfavorable factors which during that night, they merged altogether and led to a massive life-loss (only 137 survivors). Apart from the adverse weather conditions, the most distinct mistakes observed were the late actions from the Master/Bridge officers after realizing the significance of the situation and the overall insufficient actions of the crew during the evacuation, manifested by poor crowd management skills.

**Methodology**

This semi-systematic literature review aimed into identifying and providing a concentrated report in relation to the most common and significant mishaps/causes behind the problematic evacuation procedures occurring still to this day. Particular attention was paid to the current training standards and procedures, as required by the International Convention on Standards of Training, Certification and Watch keeping for Seafarers (STCW), that are followed during the certification process for every crewmember and Officer. Furthermore, as it has been claimed by many seafarers and experts in the field, the drills carried out on vessels are insufficient and/or lacking realism for covering the threats appearing during an emergency situation. Therefore, qualitative research was carried out in order to uncover the truthfulness behind these allegations and to locate the potential gaps and deficiencies occurring during these processes. Moreover, this literature review process included a research through
Various peer-reviewed articles in the open literature, attempting to provide a clear insight to the mental and psychological state that the crew and 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 impact negatively the procedures by causing further confusion and delays. Additionally, the research covered the situational constraints that can hinder further the evacuation as they are unpredictable and inconsistent, e.g., the weather conditions, speed of escalation of the damages the vessel is enduring, etc. It shall be mentioned here that relevant grey literature documents (special reports, International Codes and Regulations) were used solely or 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.

Discussion

Training

Every person wishing to join a vessel as a crew member is obliged based on the STCW Convention to undergo through a Basic Training and familiarization (STCW Reg. VI/1), where principals and knowledge concerning the survival and the duties of individuals during emergency situations can be acquired. It is understandable though that theoretical classes held ashore with limited “hands-on” involvement are insufficient for dealing with real-life situations and events; therefore, further “real life” drills are mandatory on every vessel. As per SOLAS Chapter 3, Reg. 19.3, at least one abandon-ship drill shall be carried out each month for merchant vessels and at least once-a-week for passenger vessels, to ensure the crew’s readiness for emergency situations. Furthermore, a drill within 24 h since the departure of the vessel from a port shall take place if more than 25% of the crew has not participated in a drill during the past month, or is new. Passenger ships, in case they are conducting trips that last more than 24 h, shall perform a drill including crew and passengers after departure. Since every vessel presents its own particularities, the life-saving equipment, the capabilities of every crew member and the duties of every seafarer might differ; the early familiarization with emergency procedures is crucial for the joining crew. No matter that numerous International Regulations have been adopted to ensure the survival of the people onboard during emergency situations, the question about their sufficiency still remains.

Szczęśniak (2013), supports that in many instances drills onboard ships are not given the required attention and effort, since a large number of crew members are treating drills as an additional “boring” duty that will have to fulfill during their spare time in order to satisfy the requirements of the company and the related regulations, without regarding them as a significant event that is preparing them for life-threatening moments. The research furtherly suggests that older crew member seem reluctant of repeating the same actions weekly or even monthly, as they feel overconfident with themselves and their capabilities and at the same time they tend to simplify the alarms and their responses to the minimum. Moreover, Thore Hagman in his interview (Pospolicki, 2017) stated that in large cruise/ passenger vessels with a large crew capacity, there is no consistency between the training the crew receives before joining the vessel, as the lower ranks tend to receive less training days compared to people in higher positions. Additionally, the same literature item explained that drills cannot effectively reconstruct reality conditions, as it would be extremely costly and lengthy effort and therefore several real-life emergencies cannot be replicated (e.g., list and trim of the ship). Furthermore, drills are not usually depicting the real-image of the evacuation in terms of crew and passengers, as the drill-participants are usually in good health, mentally and physically, and the crew is focusing on saving the lives of passengers and not theirs; a fact that does not conform to the reality of an abandonment.

Moreover, research suggests that one very crucial element in the successful outcome of a drill or an onboard training and in extension during a real emergency situation (e.g., abandonment), is the cultivation of a safety culture onboard a vessel (Tac et al., 2020) and a healthy communication channel between all its members. Furthermore, the safety climate which is a notion included in the safety culture, encompassing shared attitudes, standards, and perceptions around safety in the working environment (Fenstad et al., 2016) plays an important role in the emergency preparedness, as it creates a constructive relationship with the safety performance of the crew. Vukonić et al. (2016) support that in order to achieve a safety climate it is essential to create an inclusive environment where everyone can express their views and opinion on safety issues without being humiliated or unreasonably rejected. It is evident that the maritime industry does not lack of regulations and amended procedures aiming to achieve the maximum safety levels onboard a ship, but the incorrect or non-sufficient application of them creates the large-scale problem that can have fatal consequences during emergency conditions (Tac et al., 2020). The main reason behind it, are the extensive efficiency demands that dominate the maritime sector nowadays and their negative effects (Fenstad et al., 2016). Since the maximum productivity, with minimum waste of time and effort, is required during daily practices (Hollnagel, 2009), a reduction of thoroughness around safety matters is sometimes
experienced as drills tend to be postponed or poorly executed in order just to satisfy the requirements of the Conventions and regulations (Tac et al., 2020).

**Behavioral patterns of people during evacuation**

As it was previously discussed, during the evacuation of Estonia, passengers exhibited a variety of behavioral patterns; varying from very active and quick to extremely impassive. The same behavioral norms can be observed during all types of disasters that threaten human lives at sea and this is usually attributed by media or external observers to panic (Keating, 1982). Research suggests that the behavioral patterns and the feelings individuals experience are more diverse and complex. Tyhurst (1951) supports in his model theory that during a disaster three overlapping phases are experienced:

- **Period of impact**: The period where a disaster strikes (e.g., collision of a vessel), and the individual realizes that a life-threatening situation develops.
- **Period of recoil**: The period that the main danger has subsided, but the individuals experience secondary dangers and threats to their well-being (e.g., people have abandoned the vessel and are waiting to be rescued).
- **Period of post-trauma**: The victim has survived the first two phases, but faces challenges in his physical and psychological recovery.

As this paper is focused on the events and mishaps preceding the evacuation, the attention concentrates on the period of impact and the behaviors of the individuals during that time. It is estimated that during the impact period, 10–20% of the people will be able to remain relatively calm and rational and that a certain portion of them will be able to make correct decisions related to their survival. Around 75% will be dazed and unable to act effectively and probably will act in a semi-automatic manner; the remaining 10–15% will exhibit a highly ecstastic and improper behavior (Leach, 1994). Furthermore, it shall be highlighted that people are highly social creatures and are influenced to a great extent by the behavior or the actions of the others nearby. Nilsson and Johansson (2009) support through their studies that social influence plays a crucial role to the decision-making process, especially when the given or perceived information are insufficient. It is understandable therefore that every behavioral pattern experienced during an evacuation is likely to be widely influenced by the surrounding social environment.

During the aftermath of a disaster, such as the beginning of an abandonment, one of the most common behaviors observed, which can delay the whole procedure and put lives in danger, is denial. People commonly do not know how to respond to such a situation, as it is not a part of their pre-planned norms, consequently they refuse to adapt to the newly received reality. Moreover, some individuals are unwilling to trust and attain information from people who they believe that lack authority (Robinson, 2012); for instance, a passenger in Costa Concordia did not believe that the ship was sinking as the warning he received came from a dancer. Furthermore, one behavior closely linked to denial, that can extend evacuation delays, increasing therefore the danger for passengers and crew is “freezing” (Leach, 2004).

People are used to behave and act during their daily lives and activities with a pre-determined set of actions, so when faced with a shockingly new and fast-evolving condition, they tend to paralyze and remain inactive (Leach, 2005); this is happening because they cannot fully perceive and analyze the new reality in such a short time-span.

Panic, although it is not commonly observed in all types of evacuation, can be frequently observed in abandonment of vessels and can equally deteriorate the progress of a ship’s abandonment. Leach (1994) supports that the occurrence of panic behavior is commonly visible in confined spaces, where the exit routes are limited, or they are being rapidly restricted, e.g., a vessel’s compartment flooding with water. During those moments, judgment, rationality and discretion of individuals deteriorate to an extent that people might end up being self-destructive or dangerous to other (Leach, 1994). They are unable to recognize any external stimulus, communication or direction and they are focused on only one exit passage, while disregarding other less congested exits. This behavioral pattern often lacks altruism and is highly contagious among people that their need of survival takes them over completely, making harder an already difficult evacuation process.

**Unregulated factors (situational constraints)**

One of the main difficulties experienced during every evacuation process, which can also determine the outcome and the number of fatalities during every abandonment process, is the variability of the surrounding conditions. As the conditions under which every accident happens cannot be predicted or controlled in any way, the particular circumstances surrounding that event can play a crucial role to the success of the evacuation and the number of survivors. One of the most important contributing factors to the escalation of an accident is the extend of the damage a vessel has endured. Based on the JAIC Report, less than 40 minutes after the bow visor was separated from the hull of MS Estonia, the vessel had already totally sunk. It can be understood therefore that there is a close correlation between damages and the
available evacuation time. Furthermore, one element closely related to the extent of damages is the pitching, rolling and incline of the vessel that can impair the walking speed of people which is an important element during an abandonment (Gwynne & Boyce, 2016), once the decks have start being flooded. Based on experiments carried out by the Research Institute of Marine Engineering of Japan, it was observed that a heel up to 20 degrees will not sufficiently affect the walking speed of individuals, but there is sufficient ground to believe that in case that list is exceeded, the conditions can prove dangerous (Yoshida et al., 2000, 2001). The above was confirmed on both the tragic events of Estonia and Costa Concordia, where lifeboats and life rafts couldn’t be launched at their full extent and also heavy objects where moving around, endangering and confining the passage of people (JAIC Final Report, 1997 & RINA, 2016).

Furthermore, the success of an efficient evacuation can be widely impaired by the surrounding weather conditions. Waves and strong winds can seriously escalate the flooding of the vessel, as well as the related developing list. Moreover, extreme weather conditions as the aforementioned can affect the survival of crew and passengers even after they have embarked the appropriate LSA, as turbulences can even capsize life rafts and lifeboats. That was also proven during the Estonia evacuation, where the waves capsized or flooded several life rafts causing people to die either of injuries or hypothermia (JAIC Final Report, 1997). Finally, as it has been proven by certain studies, age groups of 60 years and older tend to exhibit slower movements of approximately 15 per cent, when compared to younger age groups (Bles et al., 2001). It can be understood that the older age groups or people with disabilities are a factor that is also unregulated and can impair further the speed and efficacy of an abandonment.

Conclusion
The brief literature review conducted, was focused initially to two very influential disasters of the maritime industry (RMS Titanic and MS Estonia), that resulted into a great number of casualties due to insufficient evacuation practices. Furthermore, those accidents were used as the starting point to discuss the changes and progress achieved relating to International Regulations and adopted practices such as the introduction of the SOLAS Convention, which should be viewed as the founding stone for an effective level of safety at sea and clearly sets the framework of operations for the modern shipping industry. Special attention was paid to the catastrophic event of MS Estonia, that even though it happened in the relative recent past, the vessel was conforming with all the required regulations and was equipped with the most modern equipment in terms of LSA; however, evacuating that ship and associated survival rates clearly stand out as a tragedy. Furthermore, white literature papers were used through the research in order to gain a better understanding in relation to efficiency and quality of the training the seafarers receive before joining a vessel and whether (or, not) this can be considered as sufficient. Additionally, practices and attitudes of people during the conduct of drills were discussed, in order to determine their real efficacy and to showcase the significance of the safety culture aboard a ship. Moreover, the behavioral patterns experienced by individuals during emergency situations, which can lead to abandonment delays and casualties were also highlighted and the variety of emotional stages and frequent behavioral practices was analyzed. Finally, with the use of white literature reports in a combination with grey literature, a number of the unregulated factors of shipping disasters that can impair the outcome of the evacuation were discussed. The realism level of associated crew’s training drills, as well as knowledge and competence in crowd management techniques that can help to maintain passengers calm and confident during stressful and emotionally/mentally demanding situations are all standing out as enablers to avoid casualties at sea during a ship’s evacuation.

Disclosure statement
No potential conflict of interest was reported by the author(s).

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