Automated Lifeboat Manifestation Embarkation System (ALMES): Facilitating Evacuation/Manifestation on Passenger and Cruise Vessels.

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ABSTRACT:

A plethora of catastrophic disasters resulting in numerous life-losses at sea can be noted, while searching and studying Maritime History. On a positive notion, through the course of time, the maritime industry has experienced technological innovations and advancements in many areas that truly metamorphosed the conduct of safe navigation, the radio-communications field and shed light to many chronic issues of the industry. In an epoch of various significant advancements in many areas of the operation of a vessel, it is quite surprising to notice that analogous progress has not been made in the manifestation/evacuation procedures followed today on cruise and passenger ships. It is worth mentioning that the mustering and life-boat embarkation procedures followed on many cruise and passenger vessels remain unchanged through the years, resembling the exact methods followed on the early 20th century.

This paper will explore the implementation of Radio Frequency Identification (RFID) and Near Field Communication (NFC) sensors, in the form of irremovable bracelets, as tools of manifestation during an "abandon-ship" scenario with the aim to minimize life-losses by facilitating a more effective/efficient means of evacuation and improve coordination during a ship's abandonment event. The proposed system will be capable of acquiring and recording passenger and crew information carrying the afore-mentioned bracelets, during their embarkation on their designated lifeboats via the RFID/ NFC readers installed at the entryway. Furthermore, certain past abandonment events that led to numerous casualties are examined, as well as the current evacuation procedures followed in the cruise/ passenger vessel industry. This study presents what currently exists in the market related to the aforementioned technology and examines the viability of creating a technologically developed evacuation system, having as a final target the creation and testing of a prototype.

Keywords: SOLAS (Safety of Life at Sea), LSA (Life Saving Appliance), ALMES (Automated Lifeboat Manifestation Embarkation System), Lifeboat, Evacuation

1. Introduction:

In the course of history, the impact of certain very disastrous ship accidents strongly influenced the safety developments in relation to the wider maritime industry (including the issue of evacuation). Among those accidents, there are certain cases that even opened up the opportunity to create new and/or enhance existing Conventions under the auspices of the International Maritime Organization (IMO) (Joseph & Dalaklis, 2021). For example, the sinking of RMS Titanic is considered as the main driver behind the introduction of one of the most important relevant regulatory interventions, the International Convention for the Safety of Life at Sea (SOLAS) (Dalaklis, 2017) in 1914. Similarly, the tragic loss of MS Estonia in 1994, was able to bring several advancements and alterations on the existing regulations concerning the Life Saving Appliances (LSA) and especially the life-rafts design and specifications, as well as the adoption of further requirements concerning public address systems, escape routes, etc. The relatively recent Costa Concordia accident, calls for special attention in the realms of evacuation and crowd management. Despite the fact that this vessel was sufficiently equipped with state of the art technology and LSA means that were corresponding fully to the Internationally established standards in order to accommodate all the passenger and crew needs in case of an emergency, it can be easily understood that lessons related to evacuation conditions have yet to be learned and effectively implemented (with apparent shortcomings in "soft skills" like leadership and crowd management standing out), despite the progress in technological means recorded in the past decades (Schröder-Hinrichs et al, 2012).

It is undeniable that during the past few decades, significant improvements in the fields of research and technology have been taken, leading to advancements in a wide spectrum of safety features and appliances a modern vessel is equipped with. In a modern Navigational Bridge an abundance of devices that ensure the safe conduct of navigation can be found; the Electronic Chart Display and Information System (ECDIS) which works in conjunction with the Automatic Identification System (AIS) providing real-time information about the position, the course of the vessel and additional information about the surrounding ships, is one of the most distinct examples of the technological progress that have been made. Furthermore, a significant number of satellite navigation systems like the GPS, GLONASS and GALILEO and of course the radars equipped with Automatic Radar Plotting Aid (ARPA), constitute only few of the major technological advancements, that the shipping industry has experienced and have notably contributed to the overall safety of the vessel and the people onboard (Pallikaris et al, 2016).

It shall be mentioned here that apart from the development of equipment and devices that facilitate a safer, more efficient and effective daily operation of a ship, the wider domain of LSAs has also benefitted from numerous innovative developments that have increased the level of safety and the possibilities of locating crew and passengers in case of an emergency. For example, Emergency Position Indicating Radio Beacons (EPIRBs), and the Search and Rescue Transponders have revolutionized the Search and Rescue procedures during the tragic moments of a sinking (LSA Code, 2010). Unfortunately, although numerous improvements have happened in all the aspects of a vessel's operation -as well as on the emergency preparedness and response- an analogous progress is not observed in the evacuation field, as the techniques and procedures followed during an abandonment seem relatively unchanged over time.

Inarguably, the lifeboats carried on a vessel have been considerably improved over the course of time in terms of construction standards, deploying systems, propulsion mechanisms and means of communication. Moreover, a broad variety of lifeboat davits has been developed in order to facilitate the wider spectrum of operational needs and conditions a vessel might experience during emergency situations (i.e. Gravity Davits, Fixed Davits, Miranda Davits, Free-Fall ones); all these are helping to raise the level of safety and the feasibility of launching lifeboats even in extreme conditions (i.e. excessive list, or trim). The manifestation/evacuation methods though, applied today have not followed the same development path. Especially when it comes to large passenger and cruise vessels, in relation to which is understandable that the management and the manifestation of people is more demanding, time consuming and can result in fatal mistakes. Until today, in the majority of cruise and passenger vessels during an abandonment procedure, a verbal manifestation of crew and passengers is carried out, prior to the lifeboat embarkation; this is making the whole evacuation process immensely time consuming and strenuous.

This paper presents an alternative evacuation method utilizing technologies and equipment which already exist and is used in a considerable number of cruise vessels today. The proposed Automated Lifeboat Manifestation System (ALMES) targets to revise and upgrade the currently followed evacuation methods and the serious deficiencies encompassed in them, that in the past have led to numerous casualties. It is undeniable that the majority of the accidents, incidents, mishaps and misconducts derive from the human error and its consequences. Therefore, the adoption of ALMES on cruise and passenger vessels will be able to reduce to a certain level the human involvement in the organizational process of the evacuation and consequently will restrict the occurrence of potential mistakes. Moreover, the common occurrences of large concentrations of people, elevated anxiety and stress levels, panic and confusion will be severely reduced. The aforementioned can be achieved by the application of RFID technology, which through its wide application and adoption in maritime industry (e.g. asset tracking on ports, personnel tracking on offshore platforms) has proven its reliability and cost-effectiveness (SOLAS II-1/24 and II-2/15). The main asset of the RFID technology is its effective ability to track and record a large number of tags simultaneously, during the creation and testing of ship evacuation models; thus making it the necessary "founding stone" for the creation of ALMES, that will be able to execute, monitor and record the automatic manifestation of crew and passengers during their embarkation on the designated lifeboats.

2. Methodology:

During the write up of this paper, the qualitative research method was mainly utilized. Certain past catastrophic incidents that had devastating effects on crew and passengers, resulting to mass loss of human lives and were able to reshape the balances in the maritime industry and introduce changes and advancements, have provided the triggering point for the wider research effort. Furthermore, a brief sociological research was performed through integrating input from various peer-reviewed articles available in the related 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, that can impact negatively the established procedures (standard operating procures-SOPs) by causing further confusion and unnecessary delays (Jørgensen & May, 2002). Additional material concerning faults and mishaps in abandonment processes was collected by examining reports and sources focusing on past disastrous incidents and special attention was paid to the sinking of the Costa Concordia and the particular feasibility and conditions under which its evacuation happened (Casareale, 2017). Moreover, in order to acquire a better insight and understanding of the nature of abandon-ship drills and preparations for an emergency situation on cruise and passenger vessels -but also to gain professional opinions and overviews on the problems and deficiencies experienced in mustering and evacuation of people- a small number of interviews with professional of the field were conducted (Andreadakis & Sloane, 2021).

3. Discussion:

3.1: Objectives:

The fundamental objective of ALMES is the streamlining of the ship evacuation procedure, by targeting to minimize as much as feasible the miscommunications, human errors, irrational behaviors and at the same time, improve coordination between relevant people. It has been observed that during an abandon-ship situation a wide range of behavioral patterns emerges, that affect not only passengers but also the crew. The spectrum of the feelings and responses experienced by people is very wide and varies greatly. The most common behaviors presented by individuals under life-threatening situations as an abandonment case are primal human instincts, feeling of self-preservation, ineptitude, immense anxiety and panic for the survival of themselves and their loved ones. Of course, as dictated by SOLAS Regulations (SOLAS Ch. 3, Reg. 19.3), there are certain drills that passengers undergo when they are engaged into lengthy voyages, but it is understandable that the amount of that training cannot compensate and be effectively useful to previously untrained individuals. Freezing and inability to act efficiently has also been observed on crew members frequently, even though they have taken relevant training courses and previously participated to several drills. Because of the surrounding circumstances and the stress experienced by them, they become incapable of performing their duties efficiently and consequently delay the abandonment process.

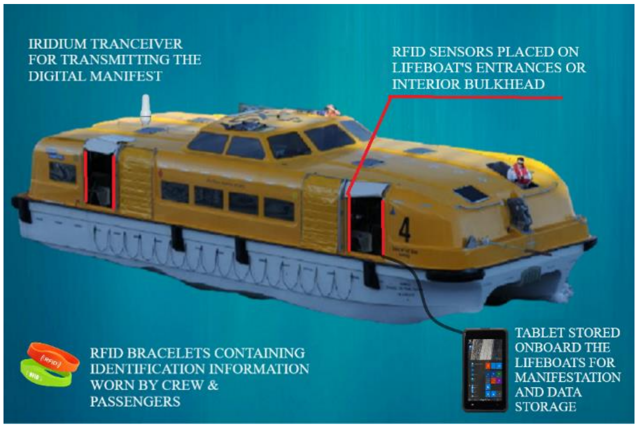
Behavioral patterns as the aforementioned, were largely observed during the sinking of Costa Concordia, where the Master's poor management and the lack of decision making from him and the fellow officers, led to an extremely lengthy abandonment of more than 6 hours (Giustiniano et al, 2016). This is in sharp contrast with the established maximum 30 minutes that are dictated by SOLAS regulations; to make matters even worse, 32 life-losses were recorded at that event. As people tend to be generally affected and influenced by the reactions and behaviors of others in the same surrounding social environment (Nilsson & Johansson, 2009), and in conjunction with the extreme anxiety and stress loads existing during emergency and life-threatening conditions, an inefficient management and manifestation of crew and passengers becomes quite probable. ALMES, by implementing the currently existing technologies in the cruise/ passenger vessel industry aims to create a pioneering solution, that will foster a safer, more effective, efficient and straightforward lifeboat embarkation in the unfortunate event of evacuation.

Furthermore, it is interesting to note that although SOLAS has introduced regulations and determined frameworks which provide guidelines and solutions on many operational and emergency issues occurring during the operation of a vessel, it has not created yet a fixed process around the mustering, manifestation and lifeboat embarkation, during an abandonment. Today, there are three mainly used evacuation practices of cruise and passenger vessels. The first and most commonly used practice is the verbal passenger counting, with the muster station leader reading from a paper passenger manifest and relaying these results to the ship's master. Secondly (and more commonly implemented on newer cruise vessels) is the use of portable computers or electronic tablets stored on the bridge under normal circumstances, which must be retrieved first by the station leader/commander during an event of evacuation. These devices communicate with each other via an interconnected onboard network, which displays digital manifests allowing evacuation leaders to relay passenger information and their health condition to the bridge via the on-board network. Although this manifestation system has eased the evacuation process, it is still performed through the use of verbal passenger manifestation, thus allowing for potential errors to occur, in a quite similar manner with the previously explained method. Finally, the most technologically advanced evacuation practice so far, that has been adopted by some major cruise operators, such as the Royal Caribbean and the Celebrity Cruises, is the accounting of passengers and crew via the use of portable handheld scanners handled by designated crew members (Ortega et al, 2020).

3.2: System Implementation Proposal:

RFID technologies over the last decade have dynamically being applied in the cruise and passenger vessel industry, ranging from onboard payments to cabin access. It would be therefore feasible by performing minor additions to the existing RFID infrastructure onboard, to extend these capabilities onto passenger management methods. By implementing the ALMES proposal, bracelets with mounted RFID technology containing all the personal information of the carriers, will be used as the proprietary component of the system. The proposed basic structure and operation of ALMES is summarized below and involves:

1. RFID bracelets containing passenger and crew personal information (i.e. body mass, age, health conditions, cabin number, family members onboard).
2. RFID readers mounted on the entrances of the lifeboats or onto the interior bulkhead.
3. Waterproof IP-67 rated, rigid electronic tablet connected to the sensors, with the necessary software responsible for the data recording of each individual entering the lifeboat.
4. Satellite modem responsible for the transmission of manifest results to the closest MRCC, upon lifeboat's launching.
5. Data connectivity between tablets via onboard wireless network (based upon GSM or WiFi), relaying information between the lifeboats and the Bridge regarding the evacuation status and embarkation conditions onboard lifeboats. The ship's Bridge will be equipped with a monitor displaying in real-time the progress of the evacuation to the ship's Master.
6. This integrated system and relevant data flow shall also be connected to the vessel's VDR, to ensure the storage of the critical evacuation information of passengers and crew.



The aforementioned systems and technologies will be designed according to the requirements and the prerequisites of SOLAS Ch. 3 Reg.4, in order to ensure the system's safety compliance. Bracelets with mounted RFID tags, containing passenger information will be read by UHF-105 readers with reading range 0 to 5 meters, with the ability to read multiple RFID tags at once, to overcome RFID tag collision, while the passengers are going through the entrances of the lifeboats. The data acquired through the mounted sensors will be transmitted to the tablet via a wired connection, aiming to avoid unexpected errors a cordless system can present, during the operation. The tablet receiving the information will be equipped with a software capable of interpreting the manifest data, displaying lifeboat occupancy, health conditions, missing individuals, and evacuation status and display the information to the lifeboat commanders, as well as to the Master through a central monitor located on Bridge; this approach will allow him/her to personally intervene, whenever needed. Furthermore, the manifestation results will be stored locally to each lifeboat on a solid state drive, along with being stored on the VDR of the vessel. Lastly, upon the launch of lifeboats the whole "digital manifest" of each craft shall be automatically transmitted via satellite communications to the nearest MRCCs.

In the preliminary design and without any commercial bias, the Iridium Satellite System was selected as the appointed transmission means of the manifestation results to the closest MRCC. The choice of Iridium technologies was performed after careful consideration and evaluation of other existing satellite systems in the market, as well as of the nature of the operation of cruise/ passenger vessels. Iridium Satellite Constellation is capable of providing worldwide coverage including the areas of polar regions, providing communication in forms of voice and data transmission. It shall be pointed out that as the operation area of cruise vessels gradually expands and more regions become approachable by the industry, the coverage of all Sea Areas (A1-A4) shall be considered of great importance; especially when it applies to emergency situations where human lives are under threat (e.g. vessel abandonment). Moreover, Iridium, after successfully fulfilling all the mandatory quality checks around the operational and technical requirements established by the International Mobile Satellite Organization (IMSO) (IMSO Website, 2022), is a certified Global Maritime Distress Safety System (GMDSS) provider from December 2019 (Sekiguchi, 2016). Since the aim of ALMES is to be capable of being installed with low cost and minimal modifications on the lifeboats, without requiring later inspection and clearance from the classification societies, the Iridium Roger ITAS Satellite Modem was selected. This particular model is an inexpensive very small, ready-to-use satellite transceiver, that will be able to be retrofitted with minimal or no alterations (e.g. use of a holding magnet) to the lifeboats, thus not requiring any later approval of the classification societies that overcomplicate and make more time consuming the installation procedure. Additionally, it is able to operate in between –40°C and +85°C, and at 75% Relative Humidity, making it ideal for vessels operating on most waterways (Iridium Website, 2022).

4. Summary and Conclusion

It is undeniable that through the years the maritime industry has taken important steps forward towards the further development of equipment and technologies, which aim to improve and reinforce the safety of passengers and crew during the operation of ships. Nevertheless, there is still an important gap to be covered, when it comes to the management of people and the lifeboat embarkation especially for cruise/ passenger vessels. The most important unresolved issue remains the failure to meet the SOLAS requirements towards the evacuation times under realistic conditions (Vassalos et al, 2002). Furthermore, the transmission of the manifestation results after a ship's abandonment remains a thorny issue, as it is frequently problematic with the accounting catalogues being incomplete or wrongly completed. The wide adoption of RFID technologies on cruise vessels in the aspects of the every-day operation (i.e. space access, onboard transactions, could be furtherly introduced to the LSA field, as per the research suggestions (Giustiniano, 2016). It is safe to say that the foreseeable growth of the RFID technologies will give space and prepare the ground for the potential introduction of the ALMES in the cruise/ passenger vessel industry. The probable adoption of ALMES will be able to promote further changes and developments in the field of passenger and personnel management and manifestation in order for the evacuation procedure to comply with the SOLAS requirements to minimize the evacuation times. Furthermore, the application of ALMES would be a contributing tool into reducing extreme behaviors, such as panic, stress, and anxiety, that are being observed during evacuation events, by reducing the human error. Finally, during the next years and after securing the required funding, as part of future related work, it is aimed to build a prototype that will be tested and evaluated in order to prove the value of the concept. This will also allow for the further development of the system under discussion even for commercial purposes and hopefully its successful integration with other relevant systems and technology applications already in use in the cruise/ passenger vessel industry.

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