

# An Automated Lifeboat Manifesting Embarkation System (ALMES): Optimizing Evacuation and Passenger Manifestation Via RFID/NFC

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**ABSTRACT:** Today, a significant number of quite advanced technology applications support safety at sea. To the dismay of the maritime industry, the manifestation of passengers during an evacuation scenario/case has not followed a similar path of improvement, when compared to the counterpart Life Saving Appliances (LSA) Code. Embarkation and muster proceedings are still following the similar approaches that were established during the early 1900s. There have been relatively few advances in these procedures; most often, they include manually checking-in the passengers on electronic systems, along with “on the spot” completion of check-off lists and passenger counts, allowing for an influx of potential error by the concerned personnel. Furthermore, the rely and transmission of the manifest to a Maritime Rescue Coordination Centre (MRCC) is often associated with a considerable amount of time, or even involving secondary passenger counts, after the disembarkation event has been concluded. It is understandable that a vessel with limited people on-board (tankers, bulk carriers, container vessels, etc.) can effectively be abandoned in a matter of minutes, but what happens with vessels carrying a large number of passengers and more specifically those heavily engaged with cruising activities? This paper examines the creation of an electronic manifestation system that will be able to automatically record the passengers during lifeboat embarkation. This proposed system will employ the use of Near-Field Communication (NFC) and/or (Radio-frequency identification) RFID bracelets, that are already utilized within the cruise industry. It will record relevant passenger and crew data, upon their boarding on the designated lifeboat, through readers installed on the parallel sides of the entryway. The data will be displayed in electronic tablet devices to the lifeboat leaders, as well as to the Master of the vessel in real-time. This will allow for an accurate representation of the evacuation process in any given moment. Furthermore, a complete “snapshot” of that information can also be directly transmitted to the MRCC via an automated message and without any further human intervention, or even stored locally aboard the lifeboats used for the evacuation and the ship’s Vessel Data Recorder (VDR).

## 1 INTRODUCTION

Over the course of time, numerous accidents at sea have resulted into an abandon-ship situation. The impact of a certain number of them was quite influential [12], such as the Titanic disaster that has paved the way for the introduction of the Safety of Life at Sea (SOLAS) convention [6] and the MS

Estonia in 1994 that highlighted the need for more effective life-raft designs and improvements of relevant regulations (Life Saving Appliances (LSA) Code), as well as adjustments to the associated training requirements under SOLAS. Of particular interest is also the case of Costa Concordia. Even though that specific vessel was adequately outfitted with all the equipment and systems prescribed in the

LSA Code, it is clear that lessons in relation to an abandon-ship situation have yet to be learned and effectively implemented (with gaps in “soft skills” like leadership clearly standing out), despite the technological progress recorded in recent years [18]. Accidents and associated lessons learned, such those mentioned above, have changed the perception of safety on-board vessels and have contributed to great progresses in the field [11].

Technology applications supporting the shipping industry are numerous; probably, the most significant progress has been made in the field of systems supporting the contact of navigation. In a modern bridge, there are various systems assisting the navigator, such as ARPA (Automatic Radar Plotting Aid) Radars (which have the ability to detect accurately and automatically plot targets), satellite-based navigation systems like GPS, GLONASS and GALILEO, various communication means, and more importantly: the Electronic Chart Display and Information System (ECDIS) that is working in unison with the Automatic Identification System (AIS) and allows for an improved situational awareness and an optimised understanding of what exactly is happening around the vessel at sea [17].

In the realm of Life Saving Appliances (LSA) research has contributed into many advancements, such as self-deploying life-rafts, Emergency Position Indicating Radio Beacons (EPIRBs), and Search and Rescue Transponder (SARTs) [8]. These devices and systems have truly advanced the level of safety at sea. Nevertheless, even though there has been immense growth and breakthroughs in technology applications and especially those related to the LSA field, procedures around evacuation of vessels have not progressed with a similar pace. It is true that lifeboats have significantly improved in terms of construction standards, propulsion systems, communications, and self-launching systems. Additionally, great effort has been placed in order to develop the davit based launching proponents that are effectively being used in all types of vessels (e.g. Gravity Davits, Fixed Davits, Miranda Davits, Free Fall Davits), with the aim to reduce the time of the lifeboats launching and make the procedure of evacuation safer; unfortunately, the methods of evacuation have not followed the same path of improvement. Today, in most passenger and cruise vessels in case of an evacuation, passengers are being manifested verbally before they embark on a lifeboat, something that makes the evacuation procedure extremely time-consuming and arduous.

As per SOLAS requirements, the time from the order of evacuation until the boat is in the water is thirty (30) minutes for passenger/cruise vessels (Annex 6.2.2.2) [9], something that is only achievable in ideal conditions and situations, as it was evident during the rather recent evacuation of M/V Viking Sky [19]. Unfortunately, in reality such figures are unobtainable during a disembarkation procedure; panic, self-preservation instinct, fear, and insecurities take control over both crew and passengers, making the evacuation procedure more protracted in time [23]. As it is evident from the historical accounts of maritime casualties, the fatalities in most of the cases (with Scandinavian Star and Costa Concordia

obviously standing out) can be attributed largely to human error and poor decision-making (before, or) after the accident and not to the accident itself [3].

In efforts to hasten evacuation times, the impact of the human element and the issues encompassed within must be removed from the equation. To effectively deal with these complications, the proposed solution could be an automation of passenger manifestation during lifeboat embarkation. The proposed method of achieving a more efficient evacuation process involves the utilization of Radio-frequency identification/ Near-Field Communication (RFID/ NFC) technology currently implemented within the cruise industry [16]. RFID systems consist of a reader with an antenna, and a transponder (tag). There are two different RFID tags available (active and passive). The active has its own power supply, while the passive does not have a power source and has to be supplied with energy given by an electromagnetic field produced by the reader.

Passive transponders or tags are available in three different RFID frequency ranges: Low frequency (LF), high frequency (HF) and ultra-high frequency (UHF). The reading range of LF and HF systems is usually only a few centimetres. UHF tags, however, are often readable over distances of more than one meter. NFC is also based on the RFID protocols. The main difference to RFID is that a NFC device can act not only as a reader, but also as a tag (card emulation mode). In peer-to-peer mode, it is also possible to transfer information between two NFC devices. NFC systems operate on the same frequency as HF RFID (13.56 MHz) systems. Therefore, there are only short read range limitations.

Recently, cruise lines have been adopting the use of the aforementioned technologies through on-board transactions, as well as an access method to several spaces within the vessel. This newly introduced piece of technology contains the personal information of individual passengers on multitude of vessels; most recently Royal Caribbean has implemented a network which enables the tracking of the passengers throughout the vessel by means of a system of RFID transponders (Oasis of the Seas - Royal Caribbean) [19].

## 2 JUSTIFICATION FOR DEVELOPMENT:

Research for this development was conducted using mainly a qualitative method, through the examination of past accidents within the maritime industry, that have had really adverse impact on passengers and crew and often resulting in the loss of human life. Furthermore, certain attributes of sociological research were applied through the analysis of the human element and reaction during times of immense stress, panic and pressure due to external influences outside the realm of control [10].

Additional data was collected through research of sources examining complications within the evacuation procedure focusing on a catastrophic incident, such as the Costa Concordia one [5]. Furthermore, a limited number of interviews were conducted with professionals of the Cruise industry

where they shared their personal views and their reactions in relation to the current hazards and difficulties experienced amidst muster and evacuation procedures undergone during simulations and training [4]. Such difficulties pertaining to passenger compliance and passenger management on behalf of the crew, and their ability to remain calm in such situations, and not to be overwhelmed by the natural instinct of self-preservation were raised [10].

The proposed Automated Lifeboat Manifesting Embarkation System (ALMES) is aiming to alleviate a certain number of issues created by the existing evacuation methods and promote innovation in a field that is considered as quite mature. ALMES aims to remove as much as possible the various errors by reducing the human involvement in the abandoning procedure and consequently eliminating potential mistakes and misconducts. Based on the proposed technology features, large concentrations of people, elevated anxiety and stress levels and the confusion created by them to both crew and passengers will be drastically reduced.

Moreover, all the miscommunication created by the verbal accounting of passengers and crew will be totally removed, as everything will be done electronically/automatically. Furthermore, due to the inability of many passengers to make way to their allotted muster stations ALMES would allow them to be properly accounted for in the case they are embarked on different of their "ordinary assigned" lifeboat. In order to safeguard passengers, a further advantage of implementing RFID/ NFC technology is that it shall be a requirement that individuals will be unable to remove their bracelets until their final disembarkation, to reassure that no passenger will forget to carry their identification at any time.

The further development of this project and manufacturing of the proposed device will enable for the automatic manifestation of passengers while embarking the lifeboat through low-range NFC or RFID technologies. These devices have been proven as accurate and cost-effective devices with the ability to seamlessly track and count individual data of hundreds of passengers who pass through the designated sensors [21]. At the same time, the relevant data could be presented not only to the lifeboat leader/commander via a designated for each lifeboat electronic tablet device, but also to a monitor located on the ship's Bridge. This will allow the Master to have an overview of the evacuation procedure in real-time without having to verify information with the persons involved with the conduct of the evacuation and add extra pressure to the intense situation they face.

Moreover, the ALMES will be capable of creating a backup of the passenger information carried on every lifeboat, storing the cumulative list in a solid state drive kept aboard the lifeboat, but also to store the data in the vessel's VDR and also "directly" transmit the relevant information to the nearest MRCC. In this way the authorities ashore will have a clear overview of the possible remaining passengers on-board and be able to solely focus their efforts on salvaging them from an early time, without having to search blindly or waiting until they have an accurate countdown of the passengers that have abandoned the vessel.

Furthermore, the evacuation of vessels will become easier and more time efficient as the passengers will need just to enter the lifeboat without having to assemble at the Muster Stations in order to be manifested prior embarkation, thus valuable and vital time will be spared, but also the crew and the passengers will feel more safe and at ease knowing that a system containing all the necessary information about them exists on-board and the only thing that should be done is to board the lifeboats and launch them. ALMES can really help to increase the safety of both crew and passengers during an evacuation.

In the past decade, the maritime industry has been associated with a multitude of evacuation missteps, due to either the aspect of human error or unaccountability and unmanageability of passengers and crew [2]. It has been observed mainly in the Costa Concordia and similar maritime incidents that the idea of effective passenger management is almost unachievable, considering the input from external factors due to panic, human error, and unforeseen influential factors (e.g. stress, fatigue, anxiety, external pressures brought on by passengers, etc.) [10].

This proposal is putting forward the development of the ALMES, which will allow for the facilitation of seamless passenger and crew disembarkation during an evacuation. It can pave the way for the reduction of personnel error and for more appropriate and accurate accumulation in regards to the manifestation of passengers during the boarding of lifeboats. Human error is kind of unavoidable and inevitable in the conduct of ship operations, with the casualty rate in an abandon-ship situation rising because of panic and the instinct of self-preservation. With the implementation of a digitalised system, a decrease in casualty rates is probable, by reducing the relevant embarkation and evacuation times. Reducing the probability of wrong decisions and actions is an additional benefit [13]. Furthermore, in recent years there has been an expansion of RFID and NFC implementation aboard vessels [15]; expansion of that use into the realm of LSAs should also be considered.

### 3 OBJECTIVES:

Since cruise vessels are designed to transport a large number of persons, who are not trained and do not have efficient experience in evacuation procedures, it should be understandable that the possibilities of panic reactions, miscommunication, etc. are quite high. Extreme reactions might not be associated only with passengers and their lack of training, but it is inevitable that these inconsistencies could involve the crew members as well. As the crew is also susceptible to primal human instinct in times of severe anxiety and immense stress, it is natural that the feeling of self-preservation could dominate and consequently prevent them from acting rationally and perform their duties efficiently, even though they have repeatedly undergone the relevant training drills.

Confusion created during an evacuation is often immense, making the task extremely lengthy and many times ineffective. This has been recorded in many cases, with a quite recent example being Costa

Concordia, where (in combination with rather poor decision making and leadership by the Captain) the evacuation of the vessel lasted more than 6 hours [7], instead of 30 minutes as per SOLAS regulations [9]. The mass concentration of passengers, their effective management and manifestation are factors that can complicate further an already difficult situation for the crew. ALMES aims to provide a solution to that and proposes a cutting edge solution that will facilitate a safer, more efficient and seamless lifeboat embarkation in the unlucky event of an evacuation. Furthermore, it is based on the wider utilization of technologies already existing in the cruise industry in order to construct a system that will assist both passengers and crew in difficult situations.

Due to no strict guideline implementation on passenger manifestation by SOLAS during mustering and lifeboat embarkation procedures, this process varies vastly between cruise line operators. Currently, there are multiple methods performed during an event of evacuation. 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 are linked to an interconnected on-board 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 platform has really improved the evacuation process, it still implemented via the use of verbal passenger manifestation, thus allowing for the possible accumulation of error much as the previous one explained method. Thirdly, the most technologically advance evacuation practice so far, which is mostly used in some major Cruise Lines such as Celebrity Cruises and Royal Caribbean is the manifestation of passengers using handheld scanners that are operated by the appointed crew members.

In this evacuation method the passengers are supposed to carry all time their cabin card, which contains their personal data and information; in case of abandonment, when mustering at the designated station, the appointed crew member is scanning the card and the passengers are proceeding to the lifeboat embarkation, while the Master is overseeing this procedure from a monitor on the Bridge [4]. This method, although it is true that it has somehow reduced the evacuation times, still has disadvantages. First of all, it is quite unlikely that in case of evacuation all the passengers will be able to remember carrying their card with them, especially when they are under extreme panic and anxiety pressure. Furthermore, the huge concentration of passengers at the Muster Stations is still creating extra pressure on the boat commanders and crew members responsible for the vessel's evacuation, who many times feel disoriented and cannot perform their duties efficiently.

#### 4 ISSUES IN SHIP EVACUATION:

It is clear by now that the manifestation of passengers at muster stations is a flawed and inefficient procedure. The passenger accounting during these events is completed in two ways, first being that of a roll call; a process that is not only lengthy and time consuming, but often inaccurate and expedited due to panic and confusion built upon by the mass concentrations of individuals around the embarkation points. Secondly is the manual scanning of each passenger and crews access card, by handheld devices carried by a Muster Station leader which are stowed in the bridge prior to the abandon ship order. These devices are not stowed in proximity of the muster points and the human congestion adds extra steps and allows for further possibilities of miscount and error. During times of high stress and anxiety many passengers do not proceed to their preassigned Muster Station, as a result many inaccuracies come about in regards to proper manifestation, leading to falsely reported manifest numbers.

All seafarers and especially the Officers joining a vessel have undergone multiple training courses, seminars and personnel management programmes in order to ensure safe, efficient, and smooth coordination of crew and passengers during emergency events as per SOLAS Ch. 3 Reg. 19 [9]. Nevertheless, in most cases of maritime casualties those trained and well-experienced individuals have been unable to cope with the panic, emotionally, and mentally challenging conditions resulting in the loss of multiple human lives. The tragic event of Costa Concordia can be considered as one of the most recent and prominent examples of human error and inability of crew to leadership in an abandoned ship situation that lead to the loss of 32 lives, sentencing not only the Master but also several crew members to prison [20]. In data presented by Lee, Kim, Park and Park (2003), it is apparent that unlike the mustering process, human organisation is far less regulated in the embarkation process due to panic and uncertainty on behalf of the passengers. A further example of human error on behalf of the passengers and crew can be seen in the 1995 abandoning ship of the St. Malo, that took one hour and eight minutes in fair seas and weather conditions, while previously under drill circumstances the crew managed to achieve just eight minutes [14].

Many human error assessments have been conducted in the realm of abandon ship, displaying that Human Error Probability (HEP) is one of the leading causes in ineffective lifeboat embarkation [2]. Through these studies it has become evident that the implementation of RFID and NFC can greatly enhance the efficiency of the mustering and embarkation process. These passenger data tracking systems as demonstrated [16], indicate a "substantial reduction in the number of incidents that pose a security risk, as well as a more efficient management of resources." These findings can be further improved via experimental validation and predicting passenger behaviour models, which would highlight evacuation routes, choices, and any other associated actions of passengers. monitored through an IR field. Based on supported models it has been proven that during an evacuation event, while many passengers due to

frustration, panic, and inefficient knowledge of the vessel, feel disoriented and unable to find the exit to muster stations. The crew based on that closed circuit RFID/NFC system could effectively detect the exact position of individuals throughout the spaces of the vessel and guide them to their Muster Stations, knowing also their personal data.

## 5 PROPOSED APPROACH DESCRIPTION:

With the current implementation of RFID technologies aboard vessels from crew and passenger location analysis and the use of such technologies in regards to payment and cabin access, it has become evident that the utilisation of this technical infrastructure is highly possible due to their widespread acceptance throughout the cruise industry. Currently vessels under MSC, Carnival, and Royal Caribbean Cruise Lines have been utilising this technology through both RFID/ NFC cards and bracelets [16]. Under the proposed ALMES system (explained via figures 1, 2 and 3), bracelets will be the proprietary components within the system's application, due to their nature of always being on the body of the person throughout their time on-board the vessel. The basic structure of ALMES will contain the following features:

- 1 1.RFID/NFC bracelets containing the carrier's personal information.
- 2 2.RFID/ NFC sensors mounted on both sides of the embarkation doors of the lifeboats.

- 3 3.Tablets connected to the sensors with an application responsible for manifesting every passenger passing through the sensors.
- 4 4.Transmission system mounted on each lifeboat, responsible for sending the lifeboat's passenger information and number to the closest MRCC, upon the launch of each lifeboat.
- 5 5.Bridge monitor and backup device connected to the Emergency Generator and to additional external batteries that will oversee the progress of evacuation and embarkation condition of all lifeboats and will give to the Master a general overview of the whole procedure.
- 6 6.Connection to the VDR of the vessel, where all the numbers and the names of the passengers will be also stored.

The above mentioned components will be designed in order to conform with SOLAS Ch.3 Reg. 4 [9] and the testing guidelines set forth by that framework. With the proposed system being able to manifest each passenger and crew member by their personal information stored on each bracelet (while passing through the sensors of lifeboats), ALMES will be able to retrieve all the necessary information and store it locally on-board the lifeboat's tablet based system, as well as it will be able to transmitted through a satellite based network (i.e. Inmarsat or Iridium), allowing for the manifest information to be directly forwarded to local MRCCs (Maritime Rescue Coordination Centres) upon the launch of each lifeboat.

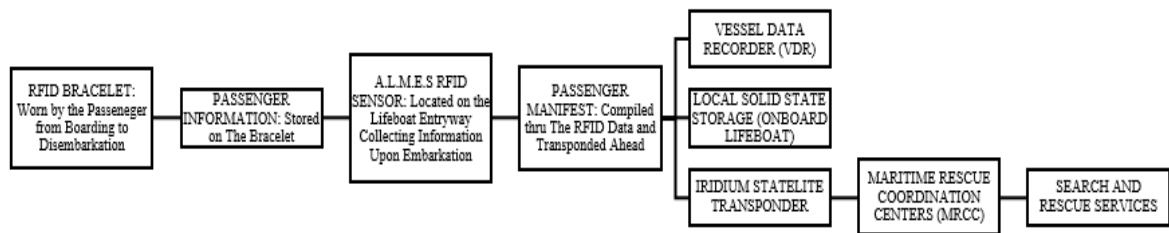


Figure 1. Evacuation Manifesting Under the ALMES Approach (Created by the authors)

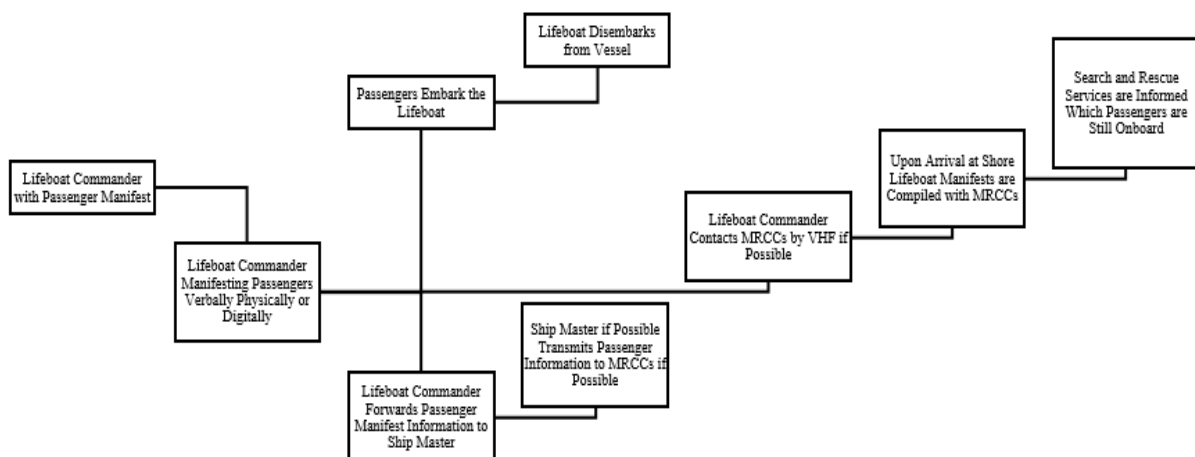


Figure 2. Evacuation and Manifesting Under Traditional Methods (Created by the authors)

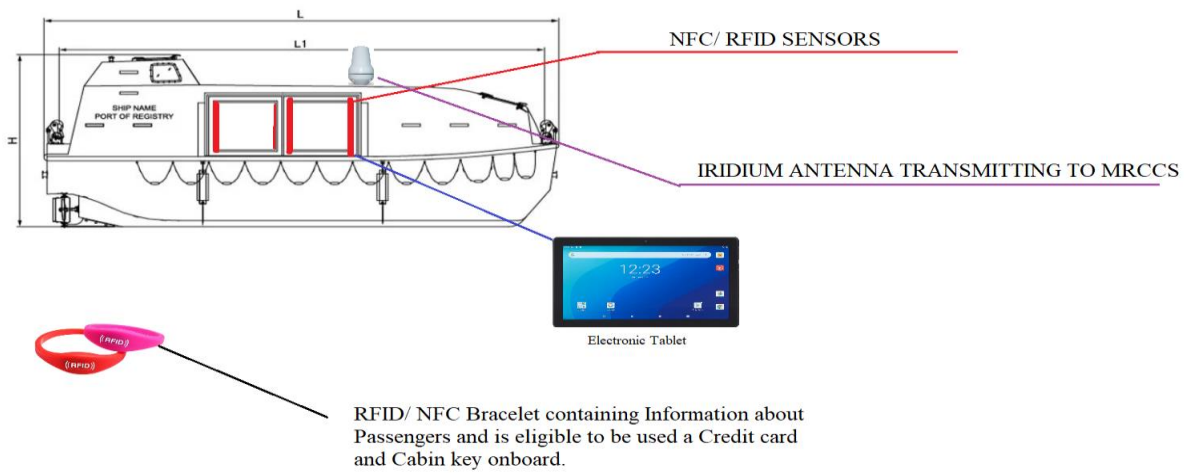


Figure 3. Current Proposal in Terms of Technical Infrastructure (Created by the authors)

In this way, the MRCCs will have a clear overview of the (possible) remaining passengers on-board and will have to solely focus their efforts on salvaging them from an early time, without having to search blindly or waiting until they have an accurate countdown of the passengers that have abandoned the vessel. Furthermore, the evacuation of vessels will become easier and more time efficient as the passengers will need just to enter the lifeboat without having to assemble at the Muster Stations in order to be manifested prior embarkation, thus valuable/vital time will be spared, but also the crew and the passengers will feel more safe and at ease knowing that a system containing all the necessary information about them exists on-board and the only thing that should be done is just to board the lifeboats and then to simply launch them. All the abandoning procedures will be overseen by the Master from the Bridge who will have a general overview of the abandoning procedure via a monitor presenting the progress of evacuation and allowing him also to intervene effectively in case he spots possible delays.

Finally, all this information will be additionally stored to the VDR of the vessel, and it could be extracted after the incident and examined in case of a possible investigation. The overall objective of ALMES is to allow for the quick and efficient transfer of information of the passengers and crew details in the case of emergency and hasten the boarding of the lifeboats. An additional aim is to bring down the possibility of life loss as well as any mismanagement on behalf of the crew, by removing strenuous aspects of the human element and at the same time streamlining the conduct of rescue operations.

## 6 COMPARATIVE SYSTEMS

Recently, technologies such as NFC and RFID are becoming more integrated into the global supply chain; this has driven the costs of such devices down and therefore making them more viable for their implementation within the maritime industry. We have seen their growth in popularity in crew management and location during every day working conditions, these systems such as IDENTEC

SOLUTION's Crew Companion system which has allowed for the real time monitoring of personnel within the working environment, from offshore platforms to commercial maritime operations. Furthermore, the Lynceus2Market project has expounded this concept and its further application during emergency scenarios [1].

With the very effective tracking of crew and passengers during events like abandoning ship and/or in the case of man overboard, this new technology application will allow the real time monitoring of individuals from the bridge and their location to be managed before they even begin the disembarkation process. Though it is apparent that these systems do not account for the boarding of the respective LSAs, the manifestation of passengers, and the transmission of the data to local MRCCS will be clearly facilitated.

## 7 CONCLUSION

Presently there are numerous indisputable issues troubling the cruise industry in the domain of passenger management and lifeboat embarkation [22]. These include the current inability to meet the required SOLAS guidelines describing ship evacuation times under realistic conditions [7]. Furthermore, it has been identified that the transmission of manifest specifics to the relative agencies can be vastly improved. Research has found that the exploitation of RFID technologies in cruise ship operations relating to on-board transactions and passenger movement can be further extended into the realm of LSAs [16].

As RFID/ NFC technologies are expected to expand further in the coming years, it makes sense to predict that the ALMES has the potential to be widely implemented within the cruise industry. It is expected that the potential introduction of ALMES on-board vessels will facilitate changes and improvements in the topics of passenger and crew management in order to further meet current SOLAS guidelines and to expedite ship evacuation times. A more precise estimation of the cost to fully develop

this system is part of future research. However, it is clear that the adoption of ALMES could be beneficial for reducing those panic, stress and anxiety levels that are existent in ship abandoning situations through reduction of the human error. It is also expected that within a timeframe of less than three years it is quite probable that the ALMES will have successfully passed all the necessary tests and evaluations related with the “proof of concept” and therefore allowing for the complete development and deployment of this system on-board seagoing vessels, further improving the level of safety and helping to preserve lives at sea.

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