IMPLEMENTATION OF A RFID SYSTEM ON SHIPS FOR PASSENGER AND CREW LOCATION

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Abstract:

Alongside the advances made in luxury and comfort in passenger ships over the last few decades, new and modern elements and protocols for the safety of the ship, passengers and the environment have also been established. At present, the major concern is to develop a more specialized security technological framework with the main objective of minimizing risks on board. It is in this area that the present work is carried out with a view to proposing the implementation of a system for locating people on board in real time consisting of the use of tracking bracelets, based on radiofrequency technology. Radio frequency technology is a technology that is now more than 50 years old, and yet it is still a technology with great potential.

Despite being a system that requires a substantial initial investment and costly maintenance, the benefits, in the short and long term, will be reflected in a substantial reduction in the number of incidents that pose a security risk, as well as a more efficient management of resources. The system applies the use of active radio frequency tags installed on the bracelets that will respond to the message transmitted by a transceiver through a series of antennas distributed throughout the vessel. By means of a series of algorithms, these antennas will determine the position of the bracelet and therefore identify the owner passenger. These devices will be operational both in the interior spaces of the ship and on the outer decks. Finally, a procedure is developed for the use of this system focused on respecting at all times the privacy rights of the passengers. As a result, and for moments of crisis on board, an efficient missing passenger location system will be obtained, along with a procedure to ensure its proper use.

Keywords:

Maritime safety, passenger ship, tracking bracelets, radiofrequency technology

INTRODUCTION

Alongside the increase in comfort and convenience that large passenger ships and mixed ships of the RO-PAX (Roll-on / Roll-off and Passenger ship) type have experienced in recent decades, new and modern elements and action protocols have been established for the safety of the ship, the passengers and the environment.

Today's demands drive us towards a security framework to minimize risks that is increasingly specialized and supported by technology. More specifically, this consists of radiofrequency technology, which is no longer a new technology, (it has been around now for over 50 years), but which is still a technology in progress with great potential.

The location of passengers by radio waves, using identification bracelets, will lead to an increase in the safety of passengers and crew, especially in the most vulnerable groups and their companions, which will directly and positively affect the reputation of the shipping company.

Passenger location by radio waves, by means of identification bracelets, will provide an increase in passenger and crew safety, especially in the most vulnerable groups and in their companions, having a direct impact on the company's reputation. Despite being a system that requires a substantial initial investment and costly maintenance, the benefits, in the short and long term, will be reflected in a substantial reduction in the number of incidents that pose a security risk, as well as a more effective management of resources.

The growth in the size and complexity of vessels, continually increasing their infrastructures located in the passenger areas, makes it increasingly necessary to verify the flows of movement of people in case of an emergency, to have them located and to be able to distribute them according, for example, to the available means of abandonment that are found on the ship. Also, during the course of an abandonment, it is essential to know where they are going, whether someone is being left behind or if they have to be redirected, allowing decisions to be made in real time and with updated values, all of which is vital for managing the emergency itself, minimizing both personal and material damage [1].

The location of passengers in case of an emergency on board is always an obstacle to the management of the emergency itself, since there will be two determining factors when it comes to managing the existing resources for the resolution of the emergency: on the one hand, human behavior, both that of the passengers and rescuers or the crew responsible for directing the passengers, and on the other the characteristics of the emergency itself and of the ship [2].

The incorporation of new technology is vital for the development of security on board. The security policy, which is normally a reactive policy (accident-regulation), has led to the implementation of various measures to reduce risks both to people, the environment and cargo and to the ship itself. However, it is a fact that risks exist and will exist, as do accidents, and that is why it is necessary to try to reduce them as much as possible to avoid a fatal outcome by applying proactive security policies [3].

To understand the benefits of a real-time location and identification system on board a vessel, we will study the possibilities that a system based on RFID (Radio Frequency Identification) technology provides, which includes the use of active tracking bracelets that operate in the UHF (Ultra High Frequency) range, in order to manage on-board emergencies, whether search and rescue or passenger management [4]. These bracelets will respond to the message of a transceiver transmitted by a series of antennas distributed throughout the vessel which, by means of a series of algorithms, will determine the position of the bracelet and the identification of the passenger to whom it corresponds.

The inclusion of this system of location and identification by radiofrequency of passengers as a security system can contribute to the better management of crowd control and passenger management in case of emergencies on board, such as for example:

- Management of the disappearance of a passenger. It is essential that the crew know how to manage the report of a disappearance of a passenger, activating the tracking bracelet protocols, achieving a reduction in the response times in the event of a possible fall overboard or the location of a minor who has gone missing.

- Location of missing passengers in case of abandonment: in the case of an emergency signal, the passengers must go to the areas designated as meeting points on the vessel and the crew must check all of these areas to ensure that nobody has been left behind. In real life, however, passengers sometimes stay in areas which the crew have failed to check or the passenger may even hide himself or ignore all of the instructions of the crew, all of which makes passenger location more difficult.

- Identification of passengers with special needs: in the case of a search for missing passengers, it will be of great benefit to the crew that is undertaking the search to know beforehand about any special needs or the physical/psychological conditions of the passengers in order to optimise the search criteria.

There are at present several real-time location systems with different uses but none of which are considered suitable for use on a passenger vessel.

GNSS (Global Navigation Satellite System) systems are global satellite navigation systems, such as the popular American GPS (Global Positioning System), the Russian GLONASS (Global'naya Navigatsionnaya Sputnikovaya System), or the European GALILEO, which are based on the calculation of the position of the user as provided by the signal received from a minimum of four satellites. They have a margin of error of between 3 and 5 metres, which could be a serious problem in the case of the search for and positioning of passengers, who may actually be in adjacent areas, but with different accesses, leading to a delay in their rescue. This is why these systems have been rejected as location systems for persons inside a premises, as in this case, inside a vessel [5].

Another of the systems that are not taken into account for indoor location systems is infrared location, since, in this technology, direct vision is essential, and due to its short range it would be necessary to place an infinity of infrared emitters, without finally achieving the objective of covering 100% of the zones [6].

The system based on the triangulation of the position by means of bluetooth devices around it is a cheap technology and one that can provide an alternative to the problem of indoor location in case of emergency, although at present, it has moved towards a more commercial use, taking advantage of the widespread use of mobile phones: information is sent to consumers when they are close to the product, or they are given directions on how to get to it. For the moment, most of these systems are short range, and their use in matters of security has not been developed, although it is a technology in progress [7].

Like the “beacons” used in bluetooth systems, Wi-Fi beacons make it possible to connect with an access point, which emits a periodic signal indicating its presence. Its study and development has taken place largely in the world of commerce and mobile telephony, where it has made and continues to make significant progress. One problem worth mentioning is the possible interference of two networks that simultaneously emit a beacon, the signal of both becoming unusable, so it would be desirable to use channels that are not heavily occupied, as well as taking into account the multipath of the signal, which must be carefully modelled before the implementation of the system to avoid areas with no signal or very reduced power [8].

Finally, GSM telephone location technology (Global System for Mobile Communications), both because of its inaccuracy, and because the environment is the marine environment, where there is normally no signal from the repeaters, is also considered unsuitable for use as a location system on a ship [9].

In sum, the objectives of this work are to propose the implementation of an efficient real-time location system, indoors and outdoors, on all passenger decks, using radiofrequency technology with a tracking bracelet, as well as develop an appropriate procedure for the use of the system, whose purpose is to provide specific actions and action processes in the event of the disappearance of a passenger and their non-location by the watchkeeping personnel, establishing the prior situation that must occur for the adoption of this procedure and always respecting the privacy rights of the passengers.

As a final result, an efficient system for locating missing passengers is obtained, together with a tool to correctly use this system consisting of an appropriate procedure that will be included in the Ship's Safety Management Manual. The system and procedure that are presented alongside the instructions on its use are designed to provide a new security tool.

1. THE RFID SYSTEM

At present, the systems of location and identification of both objects and people are experiencing a boom and are being widely developed. Our reality opens the doors to endless possibilities, from access to venues without the need to queue to get tickets, or even the fully automated purchase of clothes. Every day new ways of optimizing the resources around us arise, RFID technology becoming the norm, from supermarkets where you no longer have to go through checkout, electronic tolls, assembly lines, luggage management in airports, etc.

An RFID system is a system of remote data storage and retrieval using radio frequency. The operation is simple, as simply by triangulating the signal from different transceivers, it is possible to determine the position of the transmitter. A label containing an identification responds to the request of a sender-receiver, who reads and transmits digitally the information received to the specific application called middleware for interpretation [10].

One of the advantages of RF (Radio Frequency) waves is their ability to penetrate surfaces and obstacles to a certain extent, so that a moderate number of RFID emitters-receivers could cover a larger space than, for example, infrared or ultrasound devices, also avoiding the need for direct line of sight with the label [11].

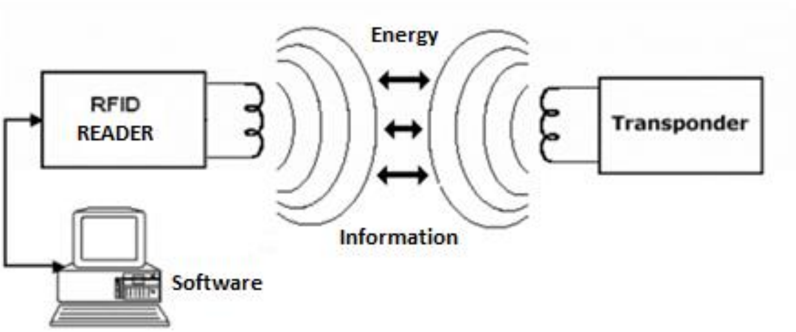
At times, due to the high propagation speed of the RF waves, the systems are combined with slower wave speed systems such as ultrasound systems, thus further reducing the margin of error when positioning the label. However, the system is not free from possible failures: multipath, reflection, diffraction and attenuation of the signal due to obstacles can cause the signal to fluctuate [12].

1.1 COMPONENTS OF AN RFID SYSTEM

The system is basically composed of the following elements[13]:

- an RFID reader transponder,
- some RFID labels,
- a susbsystem of data processing or middleware,
- antennas.

Figure 1. Diagram of a RFID system.



Source: Study, design and simulation of an RFID system based on EPC. Eduard Samà Casanovas

1.1.1 THE READER

An antenna, a transponder and a decoder form a reader. Also known as an interrogator, its main purpose is to transmit and receive signals by transforming the RF waves of the tags into a language understandable to a computer. The computer sends signals to see if there are labels in its reading range. When it picks up a response signal, it reads the message and transmits it to the data subsystem. There are readers which can edit the message of the tag thanks to integrated programming modules (if it is an editable tag).

These fundamental elements for an RFID system are usually connected to antennas, either fixed or in portable units, and can supply power to passive RFID tags. The vast majority of readers can both read and write the necessary information on the label, so that when it is read it transmits it.

Figure 2: Examples of modular, portable and fixed readers.

Sources: elion.es, zebra.com and logiscenter.com

1.1.2 THE TAGS

The RFID tag, transponder or Tag, is made up of an antenna, a radio transducer and a microchip. It transmits the identification data of the tag through the antenna. Depending on the model, it may have internal memory to store additional data, and depending on the model there are also non-reusable read-only tags or ones with which you cannot modify the message or attach or delete additional data. There is also the write-read type, with the possibility of editing the tag information.

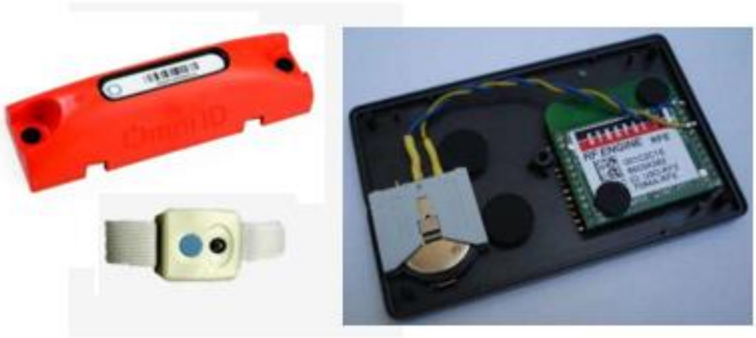
Passive tags have no internal power supply [14] and are activated when they receive the energy of a reader through an electromagnetic wave signal that induces current in the tag antenna, sufficient to power the integrated circuit, generating and transmitting a response. The reading range is usually a maximum of 5 to 10 meters, depending on the size and design of the antenna, the frequency used and the type of tag. One of the disadvantages is that in the vast majority of cases the message transmitted is brief, usually an identification number, it not being possible to expand the storage much more and transmit it.

Figure 3. Examples of passive tags.

Sources from left to right: prometec.net and fqingenieria.com

Unlike passive tags, active tags do have an autonomous power supply (usually a battery), and with it they distribute current to their integrated circuits and, via a transmitter, propagate their signal to the reader [15]. Thanks to this, they are capable of transmitting more powerful and reliable signals, with a much greater reading distance than passive tags, with clear responses to weak reception and in more difficult environments for radio frequency (metal, water ...) so they are more efficient in more difficult environments for radio frequency.

Figure 4. Examples of active tags.



Sources from left to right: kimaldi.com, aprender.tdrobotica.co and nextpoints.com

Finally, semi-passive tags are tags that have their own power supply, but unlike the active ones, this battery only feeds the microchip and is not used for the transmission of the message [16]. When transmitting, its operation is basically the same as that of a passive tag, since the energy in the radio frequency is reflected towards the reader that emits it. This design improves the response time and increases the reading range, while also having a reliability comparable to active tags and a longer service life. They may have greater memory capacity as well as additional processing functions (different sensors to determine temperature, humidity ...).

Figure 5. Examples of semi-passive tags.

Sources from left to right: nextpoints.com y vanch.net

1.1.3 DATA PROCESSING SUBSYSTEM OR MIDDLEWARE

The Data Processing Subsystem or Middleware is the specific computer application that processes and stores data [17]. It is a software that allows you to manage the message, being able to extract the useful information received by the reader, filter it and store it in a database, disposing of it when you need it. It plays the role of a translator to the language of the applications interested in the information on the tag. It can also perform the functions of peripheral device management and data routing.

1.1.4 THE ANTENNAS

The reader antennas are responsible for enabling the communication between the tag and the reader. The choice of antenna model and number will depend largely on the area to be covered for tag detection [18] [19]. Another important factor when choosing the antenna is to select the frequency range suitable for its use (figure 6).

Figure 6. Different models of RFID antennas

Source: milesdata.com

1.2 PROBLEMS WITH PRIVACY AND DATA PROTECTION

In the present era, the world of technology is evolving very quickly. However, changes in the legislation, the adoption of new laws and their entry into force does not come about so quickly. RFID technology is a technology that is growing and must be regulated to avoid the risks to privacy that may arise from its use.

In the case that concerns us, the tags being bracelets that emit a message which can be read by the interrogation network of the ship in the passenger area, and it being clear that the objective is constrained, in the case of an emergency, to search and rescue and crowd control, the system and procedures for implementing the protocol and protecting users must be very clear and specific about the protection of all the data that the tags may contain, since the users will take them with them when they disembark. Likewise, it should also be compulsory to notify the use of RFID technology, by means of signage, to clearly indicate that passengers are being subjected to its use in the different areas of the ship [20].

In any case, the system will remain inactive until its use is required, as in as the case of the disappearance of a passenger, a minor, an elderly person, etc., for crowd control in case of an emergency, or for search and rescue if necessary. Hence, in normal circumstances, there will be no signal from the interrogator and thus no response will be generated from the tag.

Upon disembarking, passengers, at the access to the vehicle decks or the gate, will have an eraser that eliminates the message written beforehand simply by bringing it close to the bracelet, if they wish).

1.3 TESTS WITH RFID TECHNOLOGY

Various tests have been devised for the development of a real-time location system using RFID technology, such as the LANDMARC study [21], which establishes a location procedure with RFID technology in an environment with and without obstacles, increasing accuracy by introducing fixed reference tags to reduce the error margins when applying the position calculation algorithm. Tests have also been performed on indoor ring overlay location based on RSSI (Received Signal Strength Indicator) [22].

2. DESIGN OF A RFID SYSTEM IN A RO-PAX SHIP FOR PASSENGERS LOCATION

Using the RFID system for locating passengers both indoors and outdoors, our aim is to transfer that idea to maritime safety, in a range of situations, which to a greater or lesser extent, occur on board a passenger ship [23].

It is quite a challenge to set up the installation required to make the system viable. However, situations as common as the location of a lost child or the location of a passenger reported by a relative as missing in the middle of the night can be managed quickly and efficiently, avoiding reaching the extremes of having to activate the man overboard protocol. In other words, the existing resources could be optimized, minimizing the reaction time and possible errors that the human factor sometimes entails. It is essential that there is a good coordination between the land offices and the ship, as passengers must come for boarding with the bracelet already programmed with their identification number.

With the establishment of this system and the development of the procedure, a rapid reaction will be achieved to a situation, which, if not resolved, can become an emergency, which would force the deployment of all the measures available on board, such as messages from the general public address system, the organization of search patrols and even notification to the authorities and maritime search and rescue maneuvers.

After activating the system, the tags will respond to the interrogators' signal, sending their unique identifier, combining it with the vessel's database, and a series of calculations that the system performs will determine the approximate place in which the label corresponding to the passenger sought is found. In this way, the person in the best position to locate the passenger can be identified.

The benefits of using RFID technology aimed at passenger location will be reflected in resource optimization, efficient incident management, anticipation of needs and of course a better business reputation and benefits for the passengers, by causing them less disturbance throughout their stay on board.

2.1 CHOOSING THE SYSTEM.

For the theoretical development of the system, its components are chosen based on their performance and characteristics. Optimal conditions are sought to address a hostile environment, as is the case of a vessel with a steel structure.

We start with the choice of frequency, type of technology (active or passive), type of tag, antenna and reader, not forgetting the data processing techniques for real-time location.

The frequency selected is UHF from 860 to 960 MHz. This provides us with a greater reading and data transfer distance. It is at present the band on which the development of RFID technology is focusing. It has a good penetration against conductive and non-conductive materials, although not in liquids.

We will use an active technology tag, with a long-lasting battery (currently more than 10 years), with its own transmitter, which alleviates the power requirement of the readers, with an “Alien H3” chip, with storage capacity of 512 bits, with read and write capability, so that the code can be changed for each new trip. The reading range is 15 meters, with a high transmission speed and the capacity to communicate with other tags.

It is a TOTAL tag (tag-only-talks-after-listening), so it remains at rest until it receives a signal from a reader, at which time it responds using its own energy. The presentation is in the form of a hypoallergenic silicone bracelet, waterproof and of different sizes, with the possibility of printing a logo on it (figure 7).

Figure 7. Silicon RFID active bracelets.

Source: http://www.primeplasticcards.co.uk

The reader will be fixed and of universal use. In our tests, it will work in the UHF frequency range, from 860 to 960 MHz, although it can be used in other ranges and adapted to other countries' regulations.

This is an IP67: BL67 modular system reader with the possibility of connecting up to 20 antennas and a reading range of up to 900 tags per second. It will use anti-collision protocols and simultaneous reading.

With respect to the antenna, it will follow the path of the other elements of the system, working in the same frequency range. The model chosen is the IANT217 (Electronics Ltd.) Omni-directional antenna, circularly polarized with a reading range of 15 meters.

On a three-dimensional plane, the irradiation of an omnidirectional antenna is uniform in all directions. It is used if coverage is required in all directions. Its radiation pattern is similar to a donut without a hole. Circular polarization is also used when tag location is unknown.

For the calculation of the position, fixed control tags will be distributed over all of the decks, creating a map that can be stored in a database which has the RSSI levels of certain static tags that are related to the tags we are trying to locate.

It is the dynamics carried out in the LANDMARC study, in which a series of algorithms take into account the levels of RRSI of the non-control active tags in relation to the control ones, that create an approximation of the tag positioning.

The RSSI will depend on the distance of the tag, since this is the strength of the signal received by the reader as a response by the tag. It can be calculated by verifying the emission range of the tag, and by extrapolation to other control tags distributed throughout the ship. Positioning systems based on RSSI can give erroneous values if the signal has suffered path losses due to the physical characteristics of the environment.

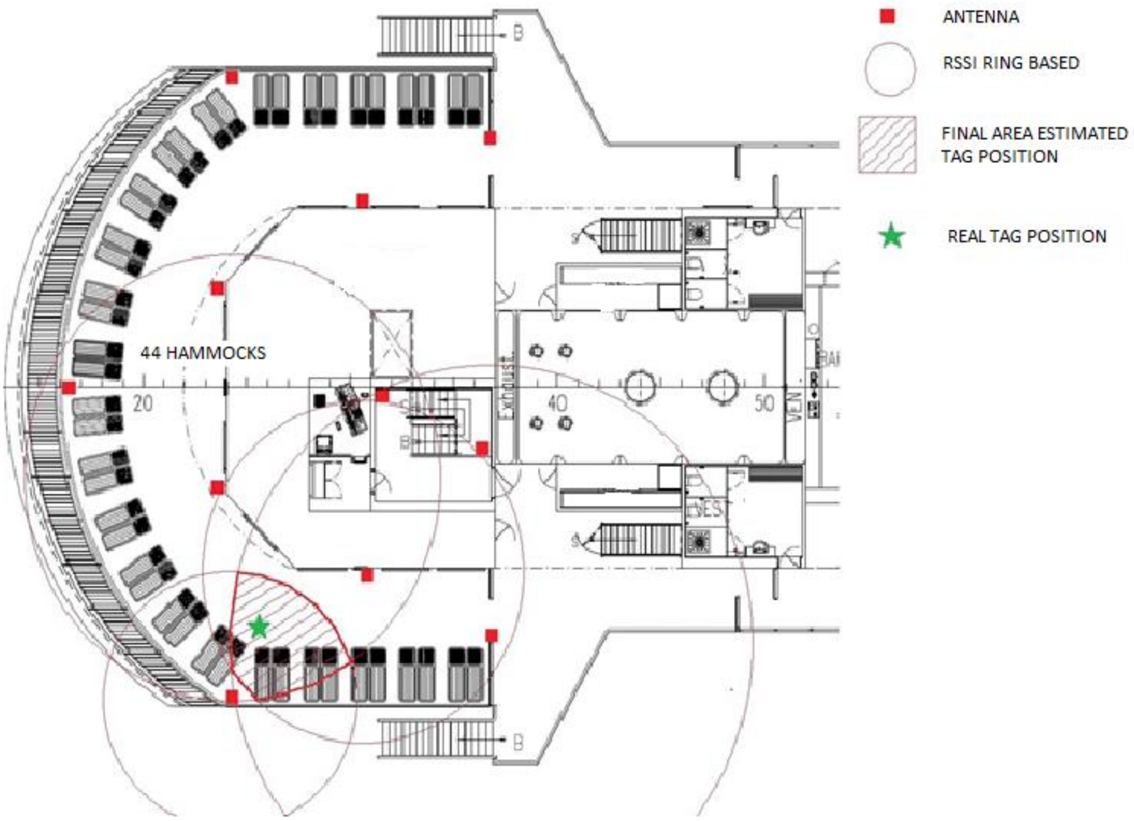
2.2 OPERATION OF THE PROPOSED SYSTEM

In the proposed scenario, tag recognition has been established anywhere on the passenger decks and inside the ship by means of at least four antennas, and whenever possible, with an unobstructed view between antenna and tag, thus reducing the chances of error. Even so, an error of approximately one meter is estimated.

Using the analysis tool, it is possible to select the tag which is to be located. Knowing the power with which they emit, the RSSI received by the reader/scan be calculated through the different antennas positioned around it. With this Reading, the radii are calculated with respect to the strength of the received signal, tracing a ring for each of the radii. The superposition of the rings based on RSSI provides an area in which, in theory, the tag which is being sought is to be found (figure 8).

The more different RSSI readings from a tag, the more precise the location, although it is also advisable to use a method of refinement to further reduce the bounded area.

Figure 8. Example of a tag location by overlay rings technique.



Source: The authors on original plans of a ro-pax ship.

3. DEVELOPMENT OF PROCEDURE FOR PROPER USE OF RFID SYSTEM

Once the RFID system is installed on board, there needs to be a written procedure that systematizes and regulates the use of the system by the crew members, which is efficient and at the same time safeguards the privacy of the passengers.

For the elaboration of this procedure, Chapter IX of the SOLAS (International Convention for the Safety of Life at Sea) of the IMO (International Maritime Organization) dealing with the safety management of ships [24], will be taken as a reference. as well as Chapter 7 of the ISM Code (International Safety Management Code) [25] entitled "Development of plans for on-board operations".

Following the guidelines of the aforementioned tools, the elaboration of a procedure for locating passengers in real time, which can be integrated into the mandatory International Safety Management Manual (ISMM) on all ships according to the ISM code, is detailed below.

3.1 SEQUENCE OF CONDITIONS REQUIRED FOR THE ACTIVATION OF THE RFID SYSTEM.

The prior conditions indispensable for the procedure to be initiated are as follows:

1º Suspicion of the disappearance of a passenger.

2º Acceptance of the conditions of use of the passenger location system, found in a clause of the transport contract previously accepted by the customer.

3º Acknowledgement that in no case will the safety of the vessel or the authority of the Captain be altered by the implantation of this procedure.

4º Understanding that the activation of the system is a complementary measure to those outlined in the ISMM.

For the activation of the system, the following series of conditions must be fulfilled:

1. Report of a passenger disappearance. The on-board service personnel, in charge of managing the incident, must take note of this passenger's data, the time at which the disappearance has been communicated, together with the data of the informant and any other relevant information.

2. Public address system announcements in common passenger areas: The type of message, repetitions and time intervals will be determined in the on-board services manual (OBSM).

3. Report to the duty officer: When the passenger is not located after repeated announcements by means of the public address system, before initiating any additional action, the duty officer must be notified and will then indicate the measures to be taken. The duty officer will coordinate a joint search by the OBS and bridge (sailor on duty) and will write down the passenger data, the time of the incident, the position of the ship and any other relevant data that he considers in the incident log.

4. Joint bridge / OBS search: Normally the on-board service personnel, together with the sailor on duty, will review the passenger decks one by one in coordination and communication with the bridge. In the case of not locating the passenger, the sailor on duty will also review restricted areas which it is considered that the passenger may have accessed without authorization, such as the vehicle deck, pet areas, etc.

5. Notification to the captain: If the passenger has still not been located, the Captain will be informed of the incident.

6. Announcement through the public address system of the ship: Two announcements will be made by the public address system of the ship that will cover all areas of both passengers and crew. The time between the messages will not exceed five minutes.

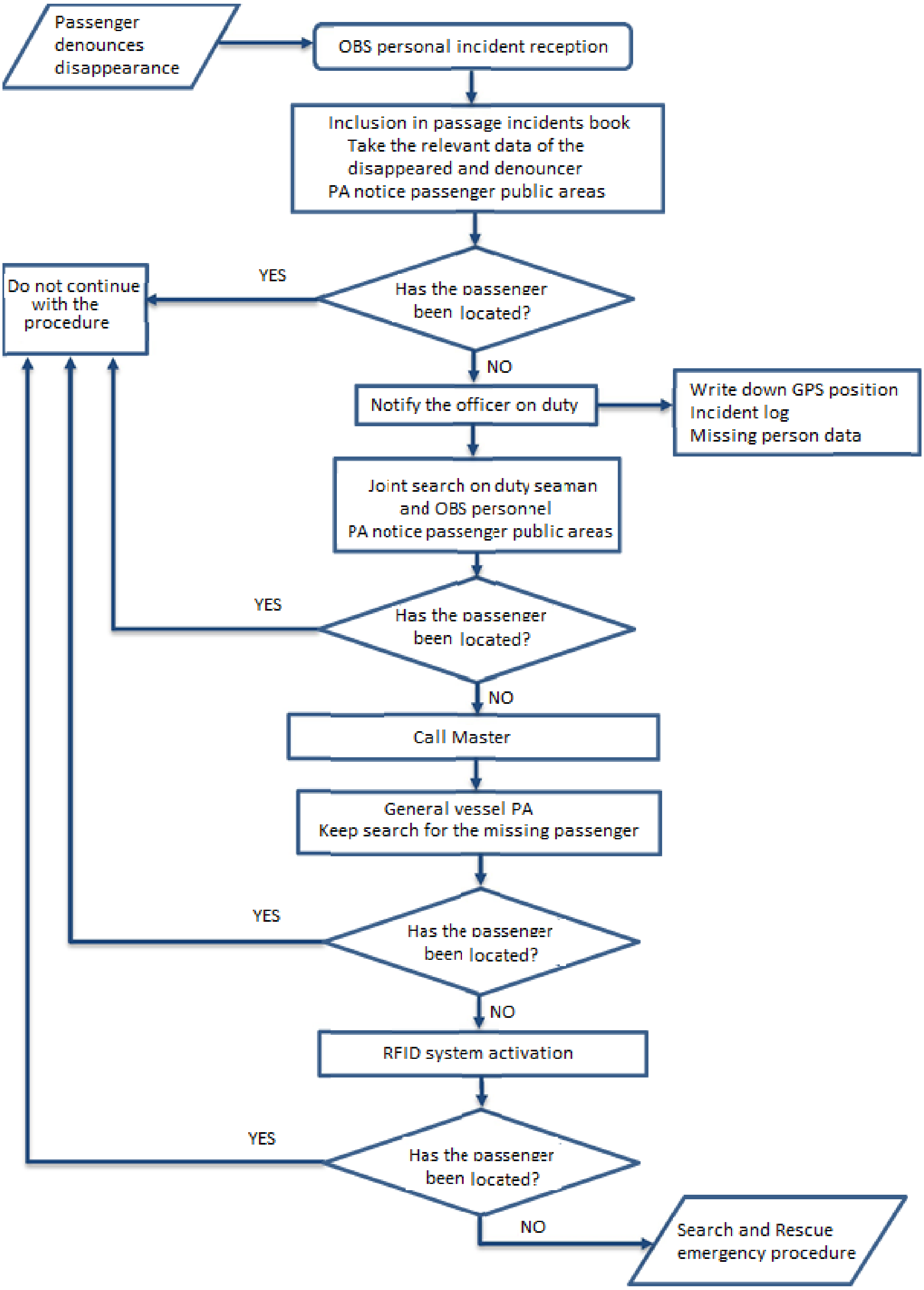
7. System activation. After the whole procedure and before declaring an emergency on board, the system is activated to detect the location of the tag of the missing passenger’s bracelet.

The conditions for the activation of the system may be altered according to the criteria of the Captain or the Duty Officer: for example, the process may be accelerated if the missing person is a minor or a person with a disability or even if the vessel is in the midst of a storm. All of these criteria will be gathered in the procedure itself, in the observations section.

3.2 FLOWCHART OF THE PROCEDURE

The main aim of the procedure is to establish a method so that the on-board personnel will perform the task adequately. The right solution to the situations that may arise on-board demands the collaboration and communication between the ship's command, the officers and the junior officers, as the success of the operations may depend on the good performance of all of the crew. It is thus essential that all participants should have some practise in carrying out their obligations and duties in each situation. The persons responsible for the company on land and on-board will act in accordance with what has been established, as shown in the flowchart in figure 9.

Figure 9. Flowchart for RFID system activation.



Source: the authors

4. CONCLUSIONS

Once the system has been completed and the procedure revised, we can conclude that:

1.- It is an efficient indoor and outdoor real-time location system.

2.- It is a system whose use implies prior acceptance by the user, through a clause in the transport contract (ticket).

3.- It is a system that complements traditional searches, increasing reliability and accuracy while reducing response times in most cases. The procedure clearly establishes the guidelines to be followed by the crew to optimize resources in case of disappearance of passengers.

4.- It is a system that does not involve any health risk and does not violate the privacy rights of the passage. It respects the rights of passengers, as the system is not activated unless absolutely necessary.

5.- It is a system that leads to an increase in passenger security, substantially increasing that of the most vulnerable groups (minors, elderly, people with reduced mobility, people with mental disabilities) since it allows an adequate reaction to the needs of the individual if necessary. As a side-effect, it will provide greater peace of mind and security to the companions of these persons.

6.- The procedure developed is a dynamic procedure, which can be altered by decision of the Captain or the officer responsible, if necessary.

7.- With regard to crowd control and directing the passengers in emergencies, using the RFID system, real-time decision making can be made, from avoiding the collapse of a point of abandonment, to redirecting the passengers to the most appropriate evacuation route. It can also be used to create descriptive models of passenger behavior in case of emergency situations.

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