An Effective Solution for Finding Persons in Water in Maritime Search and Rescue Operations

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Abstract

Search and Rescue mission established an international practice based on humanitarian traditional obligations and founded in international law. Emergences at sea are unpredictable in both timing and location and the response face many different challenges in order to achieve the goal. One of the most difficult challenges in maritime search and rescue operations is searching for persons in water. There are several ways helping in this type of searching but none of them has highly effective response due to using traditional techniques.

The paper discusses the application of person tracking by GNSS technology in maritime search and rescue operations. Which help easily in finding survivals in water either by day or night also in restricted visibility or even those trapped in sank wreck. Person tracking system combines the use of GNSS technology for locating person's and specialized software, this information can be viewed via the internet on electronic charts display.

Keywords: Persons in water, Maritime search and rescue, Persons tracking, GNSS
Introduction:

Although there are numbers of rules and articles founded specially for saving of lives at sea, but stile immense numbers are lost in passenger ships accidents due to several reasons. Also in spite there are several of applications and methods which are regularly improved in order to rescue the survivals but still their effectiveness is limited. That’s due to firstly the weakness and delayed in the distress techniques and secondly the Search and Rescue (SAR) strategy which depends on looking for ships or boats not to find the persons directly. The success SAR operations are determined by the numbers of life peoples from total number of rescued survivals, start from the time of receiving distress alert (IAMSAR, 2013). The methods of finding ship’s position after sinking and the position of lifeboats are many but the identifications of the position of persons in water is few and still immense challenge in SAR missions.

This paper discusses the importance of immediate response for rescue peoples in distress by presenting different types of passenger ships accidents, showing the number of lost lives and the methods used by the search team in response of saving their lives. According to the (IAMSAR) the International Aeronautical and Maritime Search and Rescue Manual two hours is the period of time within which survival necessity be rescued. After this period the chance to find him alive is start to diminution depending on several factors like his capability, the type of clothes dressed and the degree of sea temperature. While the period of time is too short so the response for rescue should be very fast. But the problem is how to determine the position of persons in distress individually because there are no special methods applied in SAR missions for finding persons in water.

There are several applications of GNSS (Global Navigation Satellite System) technology in determining the accurate position of a truck or a person to which it is fitted and to record the place of any of them at frequent times. A GPS following system uses the GNSS system. This system incorporates a range of satellites that use very short wave signals which are transmitted to GPS devices to give information of position, truck speed, time and direction. So, a GPS following system can actually give both real-time and historic navigation data on any type of movements. By using this technology to determine the accurate position of survivals in will potentially accelerate helping in success of searching for persons in water. (El-Rabbany, 2006)

1- Analyzing the number of lost lives in passenger ships accidents from 2002 to 2014.

The International Maritime Organization (IMO) classified the great numbers of distressed peoples in SAR mission like passenger ships accidents as Mass Rescue Operations (MRO). MRO characterized by the need for immediate response to large numbers of persons in distress, such that the capabilities normally available to search and rescue authorities are insufficient (COMSAR/Circ31, 2003). That is clarifying why there are numerous methods for saving of lives at sea and still those lives are losing that’s due to searching for large number of
survivals in a very short time and limited area. Passenger ships accidents are the rigorous example for this challenge.

After100 years of titanic accident, observing for the number of lost lives at sea in some passenger ships accidents in the period from (2002 to 2014) determining that the total number of fatalities are unpredictable. The table below shows the number of lost lives of selected passenger ships accidents equipped by the latest survival equipment’s according to the IMO regulation of Safety of Lives At Sea (SOLAS) 1979 and its amendments. The table demonstrates 22 passenger ships accidents presenting the name of vessel, year of accident and the number of lost lives in each incident from 2002 to 2014 all over the world with a total of 6695 and average of 305 lost lives per accident. It is obvious from the table that probability of accidents occurrence is two to three accidents by year which means there is no retreating in the rate of accidents during the period.

Table 1 The Number of Lost Lives in Passenger Ships Accidents in the last 12 Years

<table>
<thead>
<tr>
<th>Serial Number</th>
<th>Name of vessel</th>
<th>Year of accident</th>
<th>Number of lost lives</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>La Joola</td>
<td>2002</td>
<td>1863</td>
</tr>
<tr>
<td>2</td>
<td>Salah el din</td>
<td>2002</td>
<td>328</td>
</tr>
<tr>
<td>3</td>
<td>Nasrin 1</td>
<td>2003</td>
<td>600</td>
</tr>
<tr>
<td>4</td>
<td>U-Boat</td>
<td>2003</td>
<td>70</td>
</tr>
<tr>
<td>5</td>
<td>Samson</td>
<td>2004</td>
<td>121</td>
</tr>
<tr>
<td>6</td>
<td>Lighting sun</td>
<td>2004</td>
<td>61</td>
</tr>
<tr>
<td>7</td>
<td>Al Salam</td>
<td>2006</td>
<td>1026</td>
</tr>
<tr>
<td>8</td>
<td>Senopati Nusantara</td>
<td>2006</td>
<td>500</td>
</tr>
<tr>
<td>9</td>
<td>Al Dana</td>
<td>2006</td>
<td>48</td>
</tr>
<tr>
<td>10</td>
<td>Princes of stars</td>
<td>2008</td>
<td>800</td>
</tr>
<tr>
<td>11</td>
<td>KM Teratai Prima O</td>
<td>2009</td>
<td>200</td>
</tr>
<tr>
<td>12</td>
<td>Princes Ashika</td>
<td>2009</td>
<td>74</td>
</tr>
<tr>
<td>13</td>
<td>Coco</td>
<td>2009</td>
<td>72</td>
</tr>
<tr>
<td>14</td>
<td>Deepwater Horizon</td>
<td>2010</td>
<td>11</td>
</tr>
<tr>
<td>15</td>
<td>In sung No 10</td>
<td>2010</td>
<td>22</td>
</tr>
<tr>
<td>16</td>
<td>Spice islander</td>
<td>2011</td>
<td>203</td>
</tr>
<tr>
<td>17</td>
<td>Bulgaria</td>
<td>2011</td>
<td>129</td>
</tr>
<tr>
<td>18</td>
<td>Kolskaya</td>
<td>2011</td>
<td>53</td>
</tr>
<tr>
<td>19</td>
<td>Rabaul Queen</td>
<td>2012</td>
<td>100</td>
</tr>
<tr>
<td>20</td>
<td>Costa Concordia</td>
<td>2013</td>
<td>30</td>
</tr>
<tr>
<td>21</td>
<td>Thomas of Aquinas</td>
<td>2013</td>
<td>91</td>
</tr>
<tr>
<td>22</td>
<td>Sewol</td>
<td>2014</td>
<td>293</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>6695</td>
</tr>
</tbody>
</table>

Source: (Lloyd’s List, 2014)

The line graph below also illustrates the number of fatalities by year in passenger ships accidents the vertical axis is the number of lost lives in hundreds and the horizontal axis represent the period from 2002 to 2014. To begin, the number of lost lives fell from 1863 at 2000 to 61 lost lives at 2004 and Jumped...
again in 2006 and 2009, while remain similar from 2009 to 2010 then increased again and ended by 293 lost lives at 2014.

![Graph showing the number of fatalities in passenger ships accidents by year from 2002 to 2014. Source: (Lloyd’s List, 2014)](image)

By discussing the conditions of search and rescue operations in the last accident from the tableas anexampleSewolaccident, Sewol was chosen as it was the latest accident happened and the search and rescue procedures supposed to be used are the newest SAR techniques. According to the South Korean Coast Guard the ocean degree of temperature in the area where the ship capsized were around 12°C; at that temperature the time before the onset of hypothermia is approximately 90 minutes which means after that time the searching teams will find only dead bodies. (Web 1)

The accident is capsized and sank; happened on 16 April 2014 and type of vessel is ro-ro-passenger ferry. People on board were 478 persons (crew and passenger died 293; Rescued 174 and 11 persons were missed. Time of accident was 8:49 a.m. and at 9:40 am 150 to 160 passengers and crew jumped overboard. Rescue operation started at 8:58 am 16/4/2014 and ended on 24/6/2014. Rescue services engaged in the mission all over the search period were 171 ships, 29 aircraft, and 55 divers. (Web 2)

It is noticeable that search services started only 10 minutes after time of accident, the search team remained fairly sufficient and the place of accident was near the coast which helped the rescue team to easily reach the survivals. While all circumstances were leads to success the search mission, so why the number of fatalities are 293 and rescued only 174 persons. In order to reply this question that needs to explain the search and rescue methods to find persons in water.


(IAMSAR Manual) is the International Aeronautical and Maritime Search and Rescue Manual to assist states in meeting their own search and rescue (SAR) needs, and the obligations they accepted under the International Convention on Maritime Search and Rescue and the International Convention for the Safety of Life at Sea (SOLAS). It lies in three volumes; these volumes provide guidelines for a common aviation and maritime approach to organizing and providing SAR services. States are expectant to build up and develop their SAR services, co-operate with adjacent States and to consider their SAR services to
be part of a global system (IAMSAR, 2013). Each volume of the IAMSAR Manual is inscribed with detailed SAR structure duties, and can be used as a separate text, or, in combination with the other two Manuals, as a means to attain a full view of the SAR system. The Organization and Management volume (volume I) discusses the global SAR system concept, concern and development of national and regional SAR systems and co-operation with neighboring States to provide effective and economical SAR services; The Mission Co-ordination volume (volume II) assists personnel who plan and co-ordinate SAR processes and trainings; and The Mobile Facilities volume (volume III) is intended to be carried aboard rescue units, airplane, and vessels to help with performance of a search, rescue, or on-scene controllerfunction and with aspects of search and rescue that belong to their own crises (IAMSAR, 2013).

The International Maritime Organization (IMO) describes different types of searching for persons in water through (IAMSAR). These types depend on finding the possibility area expected to find the person within it and not the position of the person exactly. Those types illustrated below are categories in four patterns.

2-1-Visual search patterns

This type of pattern depends on the accurate determination for the most probable position of the search target, and then tries to find it by the aide of look-out. Many factors affect the accuracy to find the target some of them are metrological visibility, time of search operation whether by day or night, the effectiveness of look-out team and the type of search unites. Figure 2 below displays the visual search pattern applied by the search team during day in the M/V Sewol rescue operation, and indicates how immense the search team existed.

Figure 2: Visual search patterns carried out by search team in accident of M/V Sewol
Source: (Web 3)
2-2-Night Search Patterns

2.2.1-Parachute Flare Searches

Detection of survivors at night requires the aides of night devices like search lights or flares. Figure 3 demonstrates the usages of parachute flare by Sewol search team during the night search.

![Night Search by parachute Flare](image1.jpg)

Figure 3: Night Search by parachute Flare carried out by search team in accident of Sewol. Source: (Web 3)

2.2.2-Search by Infrared Devices

Infrared devices (IR), such as (IR) TV cameras or Forward-looking Infrared Radar (FLIR), are passive detection systems to detect thermal radiation. They operate on the principle of detecting temperature differences between the target and its surrounds to produce a video picture. Therefore, IR devices can often detect survivors by their body heat. IR devices are normally preferred for night use.

2.2.3-Night Vision Goggles

Use of night vision goggles (NVGs) can be effective in searches carried out by helicopters, rescue vessels and utility boats. There are many factors influences the effectiveness of this type of search. Some of them are quality of the goggles, environmental conditions and crew training.

2.3-Electronic search patterns

2.3.1 Survival Beacon search

This type of search initiate immediately when it is known that the target is equipped by a survival beacon, whether or not any message has been received via the Cospas-Sarsat system. As soon as the survival beacon signal is detected Search unites with homing capability, immediately directed toward the survivals.
2.3.2 Radar searches

It is useful in detecting metal objects in maritime search. The efficiency in finding the target depends on type of radar, height of antenna and presence of rain and sea clutter.

2.4-Land search patterns

Land search teams may be used to locate survivors who have left the site of a crashed plan or grounded vessel. The function of such teams is to care for and evacuate them.(IAMSAR, 2013)

It is clear from the above that the search team of accident of M/V Sewol applied the (IAMSAR) manual techniques in the SAR mission and the result is 293 fatalities. It is clear that something was lacking in the search and rescue methods or need to change in the SAR strategy.

3- Applications of GNSS technology in determining the position of the persons in water

There are several applications of GNSS (Global Navigation Satellite System) technology in determining the accurate position of a person to which it is provided and record the position at a specific time or at recurrent times. A personal locator beacons and GPS following system are two superb examples of the GNSS system applications can offers a great assistance in determining the survivals positions in the water during maritime search and rescue missions.

3-1 Personal Locator Beacons (PLB)

A PLB is an electronics device that is designed specifically to use in case of distress where time and distance from rescue service means life or death. Starting a PLB will speed up search team and easily identify survival’s position for the rescuers. As it is clear from figure 4 initiation of PLB is very simple firstly pull off the cover, secondly let the aerial work up and then push the button. PLB works on frequency 406-MHz with officially recognized worldwide dedicated search and rescue satellite network (operated by Cospas Sarsat). The PLB transmits 30second message every 50 seconds. The real time of message transmission is dithered in time so that no two PLB will have all of their messages coextensive. The PLB also have an integral global navigation satellite system (GNSS) receiver. Such the PLB uses the GNSS receiver to determine its position for presence in the transmitted digital message. In this way, the PLB will be found once it is identified by a low-Earth-orbit (LEO) or geostationary orbit (GEO) satellite.

PLB messages contain this information:

- The PLB state of origin.
- Distinctive 15-digit PLB identification.
- Position, when built-in with an integrated GNSS receiver.
This service sponsored by governments without any charges to use it. Figure 5 clarified when PLB activated, it transmits location and identification of the person to the Rescue Coordination Center using Cospas Sarsat satellites. Rescue services are instantly notified of the distress signal and regularly advised of current location. At this point, it is likely that satellite are sending your potential location, GPS coordinates demanding for assistance onto a Local User Terminal. The Local User Terminal directs the distress request to the appropriate Mission Control Centre. The Mission Control Centre where PLB is activated sent the signal to the appropriate Rescue Coordination center which matches this information with registered contact information at this point; image begins forming of where and who are the survival. That is why it’s important make sure the users keep contact particulars up to dat. (Affens. et Al, 2014)
3-2 The GNSSC following systems.

The GNSSC (Global Navigation Satellites System) consists of different types of satellites systems one of them is the GPS (Global Positioning System). The GPS system is basically consists of 27 solar powered satellites orbiting around the earth at a level of 20,183 km, ending two rotations every 24 hours, distributed on 6 orbits so that wherever the observer are there are at least 6 to 8 satellites can detect the position. (Tetley, L. 2001)

The methods of following peoples by GPS are depending on finding information about their positions at different times. This information could be either saved or send to special data base and monitoring it via internet or RF (radio waves) as it is showed in figure 6 in order to display it on specified electronic chart. The difference between GPS receiver for purpose of finding geographical positions of the persons and that for following its movement through a period of time is that the information will sent up to a third party which is for example Search and Rescue services.

![Figure 6: The process of personal following system](Source: (Web 6))

There are two main types of GPS following system.

3-2-1 a Passive GPS Following System

Passive GPS Following System will store the data of the target movements on internal built in memory or memory card attached to the system and whenever the data is needed, the memory connected to a computer to displayed and analyzed.

3-2-2 an Active GPS Following System
Active GPS Following System will display the movements of the target immediately on the computer screen fitted by electronic charts. This type as it is demonstrated in figure 7 suitable for looking of persons in search area as it sends the position information detected by GPS, and directly transmitted it via satellite network to specific computer. The accurate position of each person in water can be given individually and displayed its movements on the electronic charts. With this information and built-in clock in the receiver can follow the targets movement in the search area and easily reach them by search units.

Figure 7: A sample of personal following deviceSource: (Web7)

4-The importance of application of personal tracking system in search and rescue operations

Since the search and rescue patterns issued by the IMO in the IAMSAR for searching about persons are not specified for looking of persons directly but for searching of large area expected to find persons within it. That means the need to find innovative search pattern specialized for finding persons and track their movements on illustrated chartremains very high priorityrequirement.

Benefits of using personal tracking for passengers on passenger ships:

- Effortlessly finding and recognizing the position of each passenger individually.

-Continually search and rescue efforts during day and night even in poor visibility or bad weather.

-Effectively reach the persons in water within short time before get influenced by hypothermia.

- Doesn’t need the target to be equipped by metal reflectorto find him or affected by rain or sea clutter like in radar search pattern.

-Works continuously with direct contact to the GPS system without waiting for survival beacon signal detected by Cospas-Sarsat.
5-Conclusion:

Since the period to reach the person in distress is too short, so it is the time to change the search and rescue techniques. From searching for the persons in water through the probability search area expected to find survival within it, for another method to search directly and individually about persons in the water by the aide of personal tracking system.

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