Marine Accident Analysis with GIS

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Abstract: In this study, marine casualties which are recorded Global Integrated Shipping Information System (GISIS) in 2007-2011, result in death, injury, economic loss and environmental pollution are discussed. The studied types of ships are container, bulk dry, general cargo, ro-ro, ropax, passenger and tankers. The information contained in GISIS system is textual format and it is difficult to systematically analyze this information. For this reason, by creating a new data base, which is Microsoft Excel-based, ship accidents are classified according to name, flag state and type of ship, type, size and coordinates of the accidents that are evaluated by entering the Geographical Information System (GIS). In the study, all marine areas having been separated into ranges in ArcGIS 10 program, the marine areas with intensive marine accidents have been determined and marine accident chart has been created. As a result of the study, high risk marine areas are Strait of Dover and Hamburg in the North Europe, Belfast Shores in Ireland, the seas surrounding Great Belt, Kattegat and Copenhagen in Baltic Sea, In far east, Kanmon Strait, Urage Channel and Bungo Strait in Japan, Shanghai, Ningbo and Hong Kong in China.

Key words: Marine accidents, maritime transportation, GIS.

1. Introduction

An accident an undesired event that causes damage or injury [1]. Shipping accident is a term generally used for any accident results in financial loss, either in life or property or both [2]. The reasons for shipping accidents are many and complex [3]. However the main groups of accidental causes are human causes, mechanical causes, fire and explosion, structural causes, weather related causes and miscellaneous [4]. The cases of death and pollution at sea are mostly caused by human errors [5]. Studies consistently estimate that around 80% of causes in marine accidents are attributable to human factor [6].

Over the last decade, international maritime authorities have made significant efforts to promote safety at sea in the shipping transportation industry [7]. But there are still an enormous number of shipping accidents [8]. The lessons taken from marine accidents experienced in the history form a basis for the conventions and contracts produced for the prevention of marine accidents [9].

Therefore, accident research code has been accepted as an obligation in the 84th meeting of Maritime Safety Committee (MSC), which was held by International Maritime Organisation (IMO) in London on dates between 07th and 16th May 2008. Such code includes a safety research, recommended practices and international standards for marine accidents or marine incidents. Parties to the Convention shall undertake a marine safety research for each serious marine accident in accordance with that code and provide its findings in researches to be transferred to IMO. Within the internet site of IMO, a database is available, which is called as GISIS. This database includes a module by the name of marine incident and accident. This module contains marine accident reports which have been reported to IMO [10, 11].

In this study, marine accident data recorded in GISIS have been analysed, and they have been assessed by means of GIS in terms of marine accidents, accident...
type and accident density, and such marine accident areas with high risk have been determined.

2. Method

In this study, data pertaining to 585 marine accidents occurred during the years between 2007 and 2011, which have been recorded into GISIS, have been examined. The vessels include bulk dry, general cargo, container, ro/ro, passenger, passenger ro/ro, oil tanker, gas tanker and chemical tankers. A database has been created in GISIS system, having grouped the data recorded according to accident type, vessel name, flag, accident size and accident coordinates.

In the study, it has been intended to create marine accident chart for marine accidents, and for such purpose Microsoft Excel 2010 and ArcGIS 10 programs have been used. By means of Microsoft Excel 2010, the geographical coordinates in degrees, minutes have been converted into numerical values suitable with ArcGIS 10 program. To prevent any mistake, the accident data entered into the system have been analysed singly after the conversion. Marine accident chart has been created with the data processed once have been transferred into ArcGIS 10 program, and the created marine accident chart has been separated into ranges and risky areas have been determined.

3. Marine Accident Data

The study includes data regarding the marine accidents occurred in 2007-2011, which are recorded into GISIS marine accident and incident database and classified as very serious, serious, less serious. Very serious accidents are the accidents including vessel loss, loss of life and solid pollution. In the 37th meeting of Marine Environment Protection Committee (MESC), solid pollution has been defined as the pollution affecting the coast state or flag state, which generates serious destructive impacts on environment and requires preventive measures. Serious accidents are the incidents such as fire, explosion, collision, grounding, contact, heavy weather damage, ice damage, cracks within the body of vessel, hull flaw which do not have very serious accident nature. Blockage of main engine, underwater damage, accommodation deck damage, solid structural damages, pollution in small quantities, damages requiring shore assistance or tugboat use are included in this group. Less serious accidents are the accidents which are not as notable as very serious accidents and serious accidents and it aims at recording useful information [11]. All of the accidents analysed have been suffered by commercial vessels. Fig. 1 contains distribution of vessel accidents in percentages in terms of vessel type.

A hundred ninety six of such accidents have caused to loss of life, loss of vessel or serious environmental pollution (very serious accident). Three hundred twenty four of such have resulted in injury, small scaled environmental pollution or vessel’s becoming unsuitable for navigation (serious accident) and the remaining 65 accidents are less serious accidents other than abovementioned accidents.

Flag state is responsible for that the vessel, which has its flag, be fitted out in accordance with international life, property safety, national and international rules. Therefore, flag state practices are an important factor for marine accidents [10]. Table 1 indicates the distribution of vessel accidents recorded in GISIS according to flag state. Among accident data which have been transferred to the database, 188 accidents have been caused by the vessels with Panama flag, 83 of them with United Kingdom flag, 30 with Denmark flag, 24 with Malta flag and 23 with Liberia flag (Fig. 2).

Marine accidents have been analysed in seven categories, including collision, grounding, fire/explosion, flooding/sinking, damages to ship or equipment, occupational accident and other accidents. As a result of examination of marine accident data, it has been found that the most frequent 3 accident types are collision, grounding and damages to ship or equipment (Table 1).
Fig. 1  Distribution of vessel accidents according to vessel type.

Table 1  Distribution of vessel accidents according to accident type [11].

<table>
<thead>
<tr>
<th>TYPE of SHIP</th>
<th>TYPE of MARINE ACCIDENTS</th>
<th>Collision</th>
<th>Grounding</th>
<th>Damages to equipment</th>
<th>Ship or Occupational accident</th>
<th>Fire/ explosion</th>
<th>Flooding/sinking</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk Dry/ General Cargo</td>
<td>97</td>
<td>66</td>
<td>52</td>
<td>20</td>
<td>23</td>
<td>10</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Container</td>
<td>41</td>
<td>12</td>
<td>13</td>
<td>19</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Oil Tanker</td>
<td>14</td>
<td>10</td>
<td>4</td>
<td>9</td>
<td>6</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Chemical Tanker</td>
<td>15</td>
<td>6</td>
<td>9</td>
<td>7</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Gas Tanker</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Passanger Ship</td>
<td>4</td>
<td>7</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Passanger Ro/Ro Cargo</td>
<td>15</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Ro/Ro Cargo</td>
<td>7</td>
<td>8</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>195</td>
<td>112</td>
<td>92</td>
<td>71</td>
<td>54</td>
<td>22</td>
<td>39</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 2  Distribution of vessel accidents according to flag state.
4. GIS

GIS is an information system which performs integratedly the functions of collection, storage, processing and presentation to customer of the information, either graphical or non-graphical, which have been obtained through data or observations based on location [12]. GIS has 5 important components. These are hardware, software, data, human and method. Effective use of GIS depends on organized use of all components. The most important component is the data which requires the maximum time and cost among others [13].

Achievement of GIS project depends on availability of data with appropriate structure. In GIS, the geographical data consists of 2 main groups: verbal and graphical. In verbal data, the information, which indicates attributions of geographical data, is stored. On the other hand, in graphical data, the information, which indicates the form and location of objects in the world, is stored. Since the GIS is based on relational data model, table data and graphical data may be connected to each other. In order to transfer geographical data into computer, to process and display it in computer, said raw data must primarily be converted into a form cognizable by computer. Such a conversion is possible through conversion of data into numerical form [12, 14].

GIS technology has been a popular tool for visualization of accident data and analysis. Accident analysis studies aim at the identification of high rate accident locations and safety deficient areas [15]. The use of GIS is the most effective way of examining and evaluating the results of analyses which use a multitude of data and different criteria [16]. GIS is used to locate accidents on a digital chart and realize their distribution [17].

4.1 Implementation of GIS in The Study

Marine accidents have been analyzed in 5 stages in ArcGIS 10 program. In the first stage, marine accident chart has been created by entering marine accident data into ArcGIS 10 program. Fig. 3 indicates the distribution of marine accidents according to vessel type. In the 2nd stage, the world chart has been divided into 10 degree latitude and longitude intervals and accident density has been identified for marine accidents.

Accident density chart has been created for general marine accidents in Fig. 4, and for collision and grounding accidents in Fig. 5. In the study, marine accident areas have been classified as very high risk, high risk, moderate risk and low risk marine area. Definitions are associated with quantity of accidents, depending on the size of accident area. Accordingly, ranges with density of more than 30 accidents are very high risk marine areas; ranges with density of between 20 and 30 accidents are high risk marine areas; ranges with density of between 10 and 20 accidents are risky marine areas; ranges with density of between 5 and 10 accidents are moderate risk marine areas; and ranges with density of less than 5 accidents are low risk marine areas.

In the 3rd stage, marine areas where marine accidents are intensive have been analysed. In this stage, the North Europe and Far East have been determined as the marine areas with the most intensive marine accidents. In the 4th stage, such marine areas have been focused on. Therefore, such marine areas have been divided into grids with 2 degree latitude and longitude intervals. So it has been made possible to display and interpret the marine accidents in the North Europe and Far East comprehensively (Figs. 6, 7, 8 and 9). It has been found that such process is required for determination of marine accident locations. Such created charts enable assessment of marine accidents in terms of location.

In the last stage, marine accident charts have been assessed and interpreted. In order to provide comprehensibleness of the assessment, ranges with high accident density have been numerated from 1 to 16 (Figs. 6 and 8). Table 2 indicates quantitative distribution of marine accidents according to range number.
Fig. 3  Marine accidents chart for merchant ships.

Fig. 4  Density chart for all of marine accidents.
Fig. 5  Density chart for collision & grounding accidents.

Fig. 6  Density chart for North Europa Countries.
Fig. 7  General distribution of types of marine accidents in the North Europe.

Fig. 8  Density chart for Far East Countries.
5. Results

Marine areas with the highest risk, in terms of marine accidents, are North Europe and Far East.

The marine areas with very high risk and high risk in the North Europe are Strait of Dover between England and France, Belfast shores in Ireland, Hamburg in Germany, east coasts of Denmark and in the south coasts of Norway the seas surrounding Kattegat, Great Belt and Copenhagen.

Marine accidents in the Far East are intensive especially in the coasts of Japan and China.

In the Far East, marine areas with intensive marine accidents are Kanmon Strait, Urage Channel and Bungo Strait in Japan, Shanghai, Ningbo and Hong Kong in China.

As a consequence of a general assessment of all accidents, it has been found that especially collision and grounding accidents have high intensity in these areas.
6. Conclusion

GIS is a basic guide which provides interpretation of results on a chart. It enables visual interpretation of accidents. In this study, marine accident areas with high intensity have been visually interpreted. It is important for determining measures required to detect marine accident areas with high intensity and prevent marine accidents in such areas. Coastal areas and straits are the marine areas where collision and grounding accidents have the highest density.

GIS is a significant instrument for the follow-up and mapping of marine accidents. In this context, the usage of GIS in the field of maritime must be extended. It shall be important to determine the common reasons of marine accidents in the marine areas, with high density of accident, for preventing similar accidents.

References