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Risk analysis for RoPax vessels: A case of study for the Strait of Gibraltar

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ABSTRACT

The Strait of Gibraltar (SOG) is one of the principal navigation areas in the world. The maritime traffic registered in the area is approximately 110,000 ship movements per year, where thirty-three per cent of total traffic involves roll on/roll off passenger (RoPax) ships which run scheduled voyages between ports in the area. There are presently many accidents involving this type of ship being reported. Although these incidents have serious consequences, both based on a financial scale and regarding human safety, there is no formal maritime risk analysis study for this area carried out to date. The aim of this paper is to present the results of a risk analysis for RoPax ships operating in the SOG, based on accidents statistics covering the period 2000–2011. The work has been performed using the two first steps of the IMO Formal Safety Assessment methodology: Hazard Identification and Risk analysis. To identify the hazards and their associated scenarios and quantify, their frequencies and consequences, the Historical Accident Data Analysis and Expert Judgement techniques were used. A risk matrix has been drawn up to calculate the risk indices of the identified hazards. A comparative study of the accident frequencies obtained from similar previous studies is also presented in the paper. A high-level model risk for collisions was established through the elaboration and quantification of an Event Tree, calculating the individual and social risks. The conclusions of this study could serve as recommendations to be used in a subsequent decision making process.

1. Introduction

Ships designed to carry passengers and roll on/roll off cargo (RoPax ships) are among functional types of ships. The flexibility, ability to integrate with other transport systems and operating speed, has become extremely popular in many routes. However, as past accident statistics demonstrate, there are numerous examples of accidents involving RoPax ships. Consequences of these accidents include large numbers of lost lives, serious damage to the environment and economic costs. The capsize of the *Herald of Free Enterprise* in 1987, the fire of onboard the *Scandinavian Star* in 1990 and the sinking of the *Estonia* in 1994, are notable cases of well-known and investigated maritime casualties. Unfortunately, major maritime disasters involving RoPax ships still occurring in the last decade, as the sinking of the ferry *Al Salam Boccaccio 98* in February 2006, and more recently the sinking of *Sewol* in April 2014.

Studies relating to shipping risk assessment have received growing interest in the last years. Risk assessment has been very helpful for the review and development of new rules and regulations in order to reduce accidents and improve maritime safety. Many methods and applications for maritime transportation risk analysis have been presented in the literature. Goerlandt and Montewka (2015) present a complete review of scientific approaches to risk analysis focusing on applications addressing accidental risk of shipping in a sea area. The review covers the period from 1970 to 2014, up to a total of 58 applications.

A number of risk assessments studies applied to RoPax ships can be found in the literature. Det Norske Veritas (DNV, 1996) carried out a study on RoPax ships sailing in the North West of Europe; focusing on the investigation of operational dangers and causes of such vessels and quantify, when possible, their frequency and consequences through the creation of a risk model based on Event Trees (ET). Van Dorp et al. (2001) and Merrick et al. (2003) carried out both risk assessments on ferries at specific geographical areas, Washington state and San Francisco Bay, respectively. Otto et al. (2002) submitted a risk analysis for these ships to study the damages produced from collision and grounding. At the same time, the International Maritime Organization (IMO) adopted in 2002, the Formal Safety Assessment (IMO, 2002); a structured and systematic methodology, aimed to increase maritime safety based on risk analysis. Accordingly, we can find studies as the hazard identification related to casualties of RoPax vessels (Antao and Soares, 2006) which used the FSA methodology. Another risk analysis study for the

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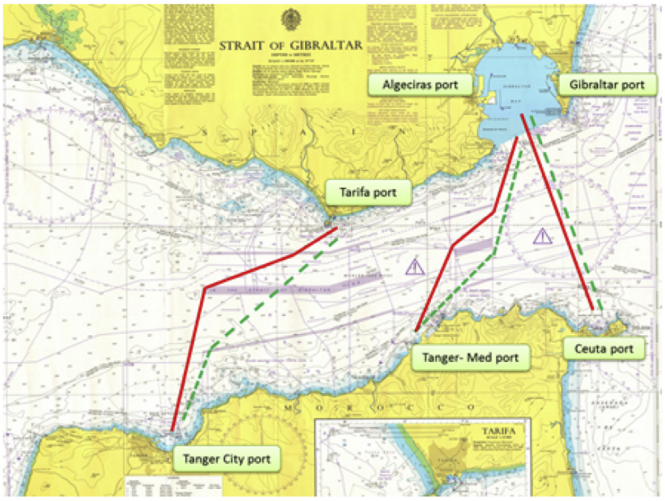

Fig. 1. Nautical chart of the Strait of Gibraltar with the ports located in the area. The continuous lines represent the southbound routes and the discontinue lines are the northbound routes performed by the RoPax ships.

world-wide RoPax fleet (Konovessis and Vassalos, 2007; Konovessis et al., 2008; Guarin et al., 2009) was carried out as part of the activities of the SAFEDOR Integrated Project (SAFEDOR, 2005–2009) and submitted to IMO (IMO, 2008a). In addition, Gemelos and Ventikos (2008) present a risk assessment on Greek passenger ships in order to estimate the safety level of Greek coastal shipping. More recently, other studies (Montewka et al., 2014; Goerland et al., 2014) are focusing in the development of a novel framework for estimating the risk and consequences resulting of open sea collisions involving a RoPax, using tools such as Bayesian Belief Networks (BBN) to calculate the fatalities risk.

On this background, in this paper we present results of a risk analysis study for RoPax ships in a specific area, the Strait of Gibraltar (SOG). There is no earlier study available in the literature to the maritime risk analysis in this specific area, with exception of (Piniella and Walliser, 2013) which, however, focused in drawing the taxonomy and distribution of maritime emergencies in the area.

The Strait of Gibraltar is one of the main shipping areas in the world. It is well-known for its high volume of maritime traffic, which is dependent on a Maritime Organization System, mainly controlled by a Traffic Separation Scheme (TSS). The aim of this TSS is to organize traffic and to avoid the occurrence of maritime accidents. However, this area is prone to problematic conditions which lead to the SOG being a hazardous area for safe maritime navigation. The weather is one such troublesome element due to the continuous winds from either the east or west; there is also frequent fog in the area. In addition, there is a limited geographical area intended for navigation, aggravated by frequent geopolitical disputes between the different states who lay claim to the waters and disagree over who has control.

Of the total traffic registered in the area (approximately 110,000 vessel movements per year), 33% involves RoPax ships, which run regular voyages between the ports in the area. In 2012, 35,925 movements of RoPax were recorded, representing an average of 98 daily movements.[1] And although these ships are extremely common in this area, they are involved in a high number of accidents as a consequence of the hazards associated to this type of transport and the area in which they sail.

RoPax ships sail in the area according to three route types connecting the following ports:

[1] Traffic data have been provided by Spanish Maritime Safety Agency http://www.salvamentomaritimo.es/.

Type: Ropax
Flag: Morocco
Built year 1996
IMO N°: 9112777
Gross Tonnage: 14,221
Deadweight: 4,030 t
Length: 136.4 m
Beam: 24.6 m
Passengers: 698
Cargo units: 60 units or 360 cars

Fig. 2. Example of Ropax ships and its main particulars.
Source of the picture: http://www.marinetraffic.com

a) Route between Algeciras port and Ceuta port
b) Route between Algeciras port and Tanger Mediterraneo port
c) Route between Tarifa port and Tanger City port

Fig. 1 shows the ports located in the area as well as the RoPax ship routes. It is noticed that these routes cross the TTS located in the area, which means the RoPax ships are constantly cut crossing the main SOG maritime traffic, increasing the risk of collision. In addition, the modification of the TTS in 2007, on the occasion of the opening of the service Tanger Mediterraneo port in 2009, has contributed on an increase of cross points of conflict in the area, particularly in the Eastern part.

RoPax fleet compromises of ferries and High Speed Craft (HSC) above 1000 GT. During the period covered by the present study there were, on average, 16 RoPax ships covering these services. One example of a common RoPax ship in the area can be seen in Fig. 2.

The aim of this study is to carry out a risk analysis for RoPax ships navigating in the SOG based on accidents statistics collected for the period 2000–2011. The work has been performed in accordance with the IMO FSA guidelines. The first objective consists of identifying the hazards and their associated scenarios and quantifying, to the extent possible, their frequencies and consequences. In order to do this, the Historical Accident Data Analysis and Expert Judgement techniques were used. A risk matrix has been drawn up which is supported by the opinion of experts in order to calculate the rates and levels of risk. Also, a high-level model risk for collisions will be established through the elaboration and quantification of an ET. It is used to determinate the safety level of RoPax calculating the individual and social risks. A study of the accident frequencies obtained from similar previous studies has also been carried out. Finally, the conclusions of this study could serve as recommendations for a subsequent decision making process.

2. Methodology

2.1. Approach adopted

The FSA, adopted by the International Maritime Organization (IMO) in 2002, is a structured and systematic methodology, aimed at enhancing maritime safety. This includes the protection of life, health, property, and the marine environment, by using risk analysis and cost benefit assessment. The last update of the FSA guidelines was in 2012 (IMO, 2012).

FSA consists of five steps as follow:

1. Identification of hazards
2. Risk analysis
3. Risk control options
4. Cost benefit assessment, and
5. Recommendations for decision-making

This paper is focused in the step1: hazard identification and step 2: risk analysis.