



## Accident Risk Factors in Conventional and High Speed Ferry Ships in Spain

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### ABSTRACT

**Objective:** studying the basic causes of marine casualties in conventional and high speed passenger ships over short distances (ferry ships). Identification of risk factors for most common accidents.

**Method:** a study of working conditions and operational management of the ship in five conventional and high speed ferry ships. Analysis of the causes of accidents occurred in ten ferry ships, conventional and high speed ones. The interaction between these aforementioned studies is presented.

**Results:** Relationship between risk factors for accidents due to lack of time and poor maintenance of ships and equipment, and causation of accidents at sea in such ships and lines.

**Conclusions:** the poor implementation of the ISM Code, underlying cause of marine casualties in this type of vessels and lines, can lead to lack of time and poor maintenance as factors of risk of accidents; routine, typical in these trades can generate excess of confidence, another important risk factor for occupational accidents and maritime accidents, as well as it is noted the presence of other risk factors common to other ships and lines, such as fatigue and multifunctionality due to the reduction in crews and to a poor legislation.

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### 1. Introduction

The European Maritime Safety Agency (EMSA) has just published the "Annual Report on Marine Accidents 2009" occurred in European Union waters. It seems that the results are encouraging given the marked decrease in accidents (19,5%) except in the area of passenger ships where the percentage increased compared to 2008. The number of passenger ships involved is 135 (90% are ferries) and assume 22% of all accidents. As for the data provided 43% of accidents are allisions, 22% are groundings, 15% are collisions and 8% are fire and explosions.

This Case Study is a reflection on safety in conventional passenger ships and high speed ones, which have regular lines and do more or less short voyages (ferries). The study shows that the ineffective implementation of the Safety Management System, whose most obvious materialization in this type of ves-

sels and lines is the lack of time, may be not only the main basic cause of marine casualties, but may trigger various immediate causes, both in terms of unsafe acts and unsafe conditions.

These lines are characterized by being subject to a schedule, both for navigation and port operations, schedule that in occasional periods can be continuous. Stops are few and are scheduled (other than force majeure): apart from them, the to continue the operation. This requires good time management and effective maintenance. The routine is also a feature of these lines: same seaways, same harbours, same berths and same manoeuvres. This can lead to overconfidence, another major risk factor for labour and operational accidents.

On the other hand, it is characteristic in these vessels that almost all of the time is used in their operation: manoeuvres, loading or unloading of people and vehicles, navigation functions, etc., being especially low in these vessels available time for maintenance.

Add to that the growing trend towards the reduction in crews that brings negative consequences, such as fatigue and multifunctionality, and flags of second register that can bring an associated drop in crew qualifications, it is obtained as a result some poor working conditions that if they do not have adequate control can lead to the emergence of various risk factors of accidents and marine casualties.

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Lack of time is caused mainly by the idiosyncrasies of this type of navigation, that has to comply with schedules. This can lead, among others, to the onset of fatigue (main risk factor for accidents in the transport sector), stress, voluntary transgressions, lack of maintenance and, as in the road, excess speed, all of them risk factors of accidents.

Ineffective implementation of the Safety Management System, ISM Code, Chapter IX of SOLAS, not only has an impact on the safety of the ship (Chapter 7), but may compromise the Chapter 8, Emergency. In this work, special emphasis will be made on the impact in Chapter 10, Maintenance.

## 2. Background

In the late 80s and early 90s it took place at the international level, a series of accidents with extremely serious consequences, including the capsizing of the ferry *Herald of Free Enterprise* in 1987 with 193 deaths, the collision of the *Bow Bell* and *Marchioness* (pleasure boat) in 1989 resulted in 51 deaths, the grounding of the *Exon Valdez* in the same year, resulting in the spillage of 37000 tonnes of crude oil into the sea, the fire on the *Scandinavian Star* ferry that killed 158 people in 1990, the stranding of the *Aegean Sea* in 1992 and the *Braer* in 1993 with 74000 and 85000 tonnes of oil discharged to the sea. These accidents, which occurred in coastal waters of developed countries, whose vessels involved were crewed by experienced seamen, raised the alarm to the maritime community that there was the urgent need to investigate the causes of such accidents, with the ultimate aim of finding solution to this "spiral of calamity" in the field (Anderson, 2002).

So at this time, several studies on the causes of maritime accidents were conducted to put conclusions invariably to human error as a trigger of 60 to 80% of accidents at sea, offering at the time an idea of the importance of quality of working and living conditions onboard (in relation to the state, maintenance and management of the vessel), and the quality of crews (in relation to their knowledge and professional skills) have on maritime safety, and exposing the need for new maritime safety regulations focused on the human factor with the idea of improving such living and working conditions on board (it is continued with the Action Plan 2006-2011, to achieve rapid and widespread ratification, and effective implementation of the Maritime Labour Convention 2006, the ILO, which has not yet received enough ratifications).

The literature on the subject locates the birth of the International Safety Management Code (Resolution A741(18) International Management Code for the Safe Operation of Ships and Pollution Prevention) just after the accident in 1987 of the *Herald of Free Enterprise* ferry, which killed 193 people when capsized four minutes after leaving the Belgian port of Zeebrugge with the bowdoor open with the sea calm and in shallow waters, and whose research brought to light serious problems in management between ship and shore company. "the official enquiry into the accident revealed major error on the part of management. The judge who conducted the enquiry described the ferry's operating company as infected with the disease of

sloppiness at all levels (Rodríguez & Campbell, 2005:4). The *Estonia* ferry disaster in 1994, similar in its causes to the *Herald* one, which took 852 lives, has accelerated its implementation.

This code provides shipping industry the most complete and important legal tool aimed at improving safety at sea from a preventive point of view presented in the history of the International Maritime Organization, and has as its primary objective the reduction of accidents during the operation of the vessel by means of unconditional commitment of shipping companies in safety on board and ashore. Also, and for the first time, it is taken into account requirements relating to, inter alia, the authority and responsibility of the company and the captain, qualification, certification and working conditions of crew, the need for operational and emergency procedures on board, and the obligation to report accidents and incidents on board.

One of the innovative points that are covered by the ISM Code, which we will focus on much of this article, relates the need of establishing procedures to ensure proper and effective maintenance of the ship, by conducting periodic inspections and taking appropriate corrective actions. Similarly the concept of "critical equipment" is introduced as one device or technical system whose sudden operational failure can result in a potentially dangerous situation, also those devices or systems that are not in continuous use are part of this concept. For such equipment we have to establish specific measures designed to promote reliability:

"10.1 The Company should establish procedures to ensure that the ship is maintained in conformity with the provisions of the relevant rules and regulations and with any additional requirements which may be established by the Company.

10.2 In meeting these requirements the Company should ensure that:

1 inspections are held at appropriate intervals

2 any non-conformity is reported, with its possible cause, if known;

3 appropriate corrective action is taken; and,

4 records of these activities are maintained.

10.3. The Company should establish procedures in its safety management system to identify equipment and technical systems the sudden operational failure of which may result in hazardous situations. The safety management system should provide for specific measures aimed at promoting the reliability of such equipment or systems. These measures should include the regular testing of stand-by arrangements and equipment or technical systems that are not in continuous use.

10.4 The inspections mentioned in 10.2 as well as the measures referred to in 10.3 should be integrated into the ship's operational maintenance routine"

Preventive maintenance thus acquires a priority role in the management of the vessel directly related to the safety of herself, her crew and her cargo. A study made by the Japan International Cooperation Agency, for example, concludes that most of the fires on ships start in the engine room, and are often caused by lack of proper maintenance. This agency notes

that many accidents could be prevented establishing monitoring and inspection plans and carrying out proper cleaning and overhauling. Also a ship which is not conducted and adequate and effective maintenance will suffer damage to her hull and her equipment at short notice, leading to the collapse of her commercial viability.

In these times when ships are under enormous time pressure, and short turnarounds do not allow the crew, busy with many activities essential to the operation of the ship, extensive or unexpected maintenance work, the establishment of a Planned Inspection and Maintenance System, as indicated from DNV (Bergmann, 2008), can yield great benefits to the ship and her shipping company, such as a monitoring and ongoing maintenance of hull and equipment, better planning of major maintenance work through early detection of problem areas or an increase in the motivation of the crew through the delegation of tasks. On the other hand, although the ISM Code is clear about the burden of maintaining the ship in her operational management, data from the Lloy's Register of Shipping (Graaf, 2010) show a significant number of non-conformities detected in the pre-certification inspections related specifically to maintenance problems on board (the lack of maintenance is second in the statistics of non-conformities of the Classification Society).

This July 1 entered into force the resolution MSC.273(85) of December 4, 2008, on amendments to the ISM Code. The new wording of the section 10.3, and referring to critical equipment, clarifies that responsibility rests solely on the company, which must determine the risks associated with such equipment and systems and also ensure that the methodology of risk assessment has been applied to develop and include the procedures in the Safety Management System (McFarlane, 2010).

### 3. Method

As the main objective of this article is to study the consequences of lack of time in the operation of these vessel for maritime safety, it was taken as reference the incidence of this phenomenon in two department of utmost importance: the bridge and the engine room departments. In turn the focus of study takes two different paths:

- As for the lack of time in the work in the engine room it stresses the special impact on maintenance of equipment. Accordingly the deficiencies and risk factors to which it gives rise are identified. It also examines the maintenance conditions in five passenger ships.
- As for the lack of time in the work in bridge department it stresses the special impact on the navigation speed. Ten accidents at sea on passenger ships are studied.

For the investigation and proper analysis of marine casualties the guidelines of the Code for Investigation of Marine Casualties and Incidents adopted by resolution A.849(20) of the IMO were followed. For the investigation of human factors it was followed the Reason model, recommended by IMO and ILO (Resolution A.884(21)), and which the ILO itself states and summarizes: a useful way to examine the cause of accidents

and highlight the complexity of the same, illustrated by what is known as "Reason Model". Designed by Dr. James Reason of Manchester University, UK, this method is not limited to considering the immediate circumstances of the accidents, but analyzes the preconditions of the event itself.

The first part of this article examines the working conditions in five ferry ships and depending on the concentration in location of the deficiencies found (engine room) its causality will be established.

The second part presents the results of causality analysis of marine casualties in ten cases in which 12 ferry ships have been involved.

#### 3.1. Working conditions in passenger ships

The following are the working conditions of passenger ships under study in this first part, its geographical setting and some aspects of its organization.

The five ships under study correspond to the category "Passenger/cargo ro-ro ships", and four of them have distinction of being SHC (special high speed crafts, commonly known as "fast ferries"). The speed of these last mentioned ships range from 26 to 33 knots, whereas in the case of conventional ferries does not exceed the value of 17 knots. Its geographical setting is at crossing between the Iberian Peninsula and the Balearic Islands, and Inter-island voyages.

Crews meet the minimum standards of Training, Certification and Watchkeeping reflected in STCW Code and consist of the number of seamen assigned by law to comply with the minimum manning of the organic staff for each vessel.

As for officers, on ships referred to as "fast ferries", the staff consists of master, chief engineer and first officers of each department. In the summer time, when daily trips are more numerous, there are second officers on deck to cope with the workload in the loading and unloading. Navigation hours vary between nine and sixteen hours a day. To this it must be added the time required for loading and unloading of vessels. Usually the loading operation begins one hour before leaving and unloading ends an hour after arrival in port. The periods of campaign of officers of such vessels are normally three months at sea, but sometimes the company reduces to one month the period of navigation to some of its ships in order to compensate for the excessive working load (in terms of cumulative fatigue, it must be noted that in this vessels the quick reflexes and immediacy of the response should be in keeping with the speed at they sail).

Engine room staff, crew and catering make campaign for three months, perhaps on the grounds that while sailing they have time to rest, although the frequency of working sequence prevents recovery of accumulative fatigue.

It is manifested as usual that all navigation is attended only by the Captain, as deck officers use this time to carry out monitoring of the catering department and passenger service; also they perform another safety and maintenance work, in these cases with the help of junior staff that should be resting this time.

The operation of engine room department is similar. While sailing they are on the bridge, where there are the controls of

the engine, pending the proper functioning of the propulsion of the vessel. Once in port, they should carry out maintenance and repair works of various ship equipment, as well as managerial and administrative tasks.

Moreover it must be added the time spent in bunkering operations, drills and emergency exercises. The last two occur in the periods off watchkeeping or sailing and are compulsory for all the crew. The following summarizes the study.

### 3.2. Shortcomings in working conditions

As it can be seen in Figure 1, more than half of the identified deficiencies, as detailed later in this article, are located in the engine room (54.5%), then bridge and deck make together 18.2% (bad condition of facilities, lack of instruction, etc.), holds and car decks meet 11.3% (tins, cans, flammable goods, etc.) and finally 16% of deficiencies are found elsewhere not centralized (no order and bilge cleaning, bow thruster locker and other store rooms).

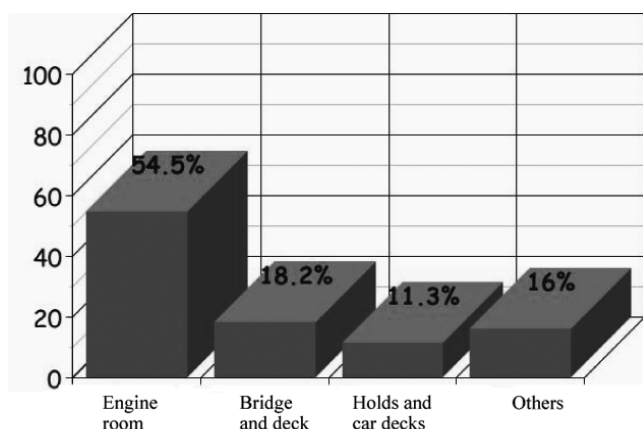


Figure 1. Deficiencies location.

As for deficiencies found, Figure 2, it can be distinguished:

1. Those related directly with the crew, 50%: so as very short turnaround, excessive working hours, reduction in crew, lack of management and leadership.
2. Those that need an economic investment to be corrected (as well as change of company policy) 29.5%.
3. Those that should be solved by the crew, but they require resources from shipping company (spare parts, for example), 20.5%.

Below are the most common deficiencies among the ships to be studied:

- The existence of hot surfaces (> 200 C in some places) without protection or thermal insulation in very poor condition, poor or lack of protection in hydraulic hoses and pipes that contain flammable liquids, along with excessive vibration in the hydraulic unit and fuel leaks are a clear fire risk factor (in addition to a clear deterioration in the environmental quality of the engine room) (Figures 3).
- The failure in detection and fire fighting systems, as well as crew lack of familiarity and training and with a clear margin of technical development, enhance further more, if possible, the paragraph above.

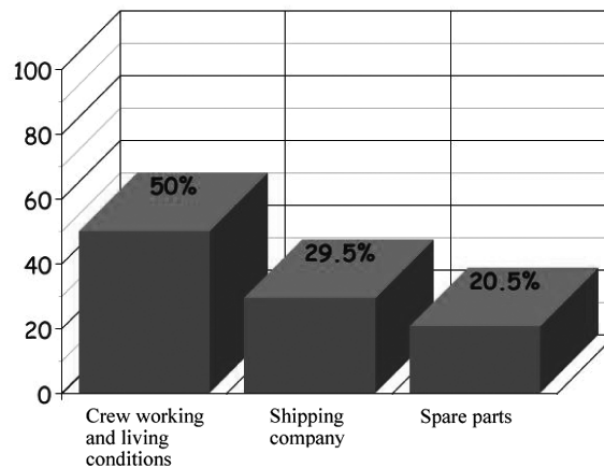


Figure 2. Deficiencies origin.

— Active alarms during navigation caused by damage and not repaired sensors, making it very difficult to distinguish a real alarm from a false alarm. The repetition makes officers think in false alarms (alarms, watertight doors, fire fighting doors, engine failure alarms).

— Absence of report of breakdowns, frequent inspections, control of preventive and corrective actions (deficiencies, mostly seems to be repeated over a period of four years), lack of predictive analysis, failure in the adequate communication between crews and intensive working days (two officers cover a shift of 24 hours due to the reduction in crews). All this form management conditions that need to be improved.

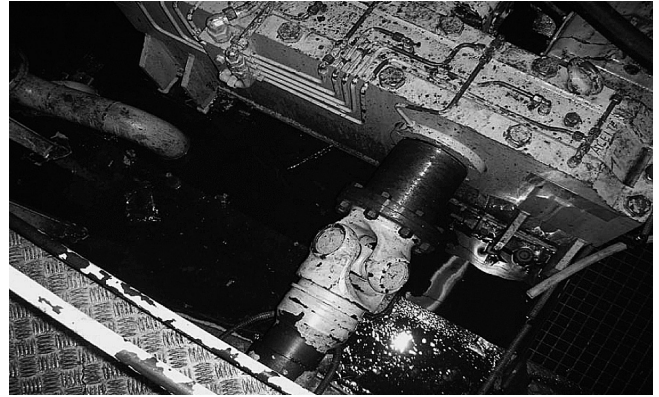
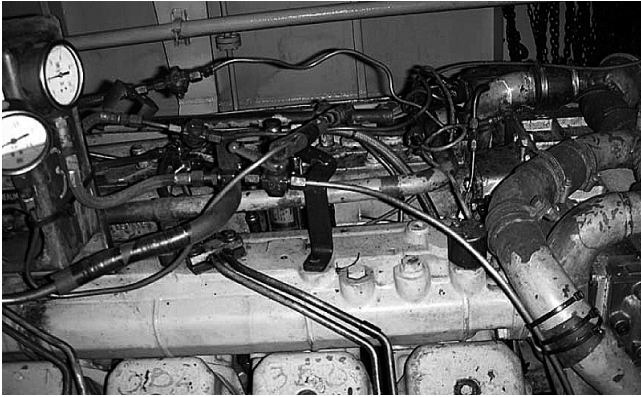
Other deficiencies, not related to the engine room or to maintenance, but listed as a cause of accident claims discussed in the following paragraph, are among others: electronic chart system is not connected to the radar (not listed positions of other vessels), absence of night vision binoculars, radar use in inappropriate scale, incorrect change or use of joystick, and lack of voyage plans (Figure 4).

### 3.3. Maritime accidents on ferry ships

The Standing Committee of Investigation of Marine Casualties (since 2008 Standing Committee of Investigation of Accidents and Incidents, CIAIM) under the Ministry of Development, from Spain, has as main aim the determination of technical causes of maritime accidents occurred in waters and /or vessels under its jurisdiction.

The following is a summary of the analysis on maritime accidents focused on those in which at least one passenger vessel has been involved (according to data published by CIAIM, [www.ciaim.es](http://www.ciaim.es)). These passenger ships under review, conventional and high speed, continue to trade mainly in waters with a certain density of traffic: Balearic Islands, Iberian Peninsula, Strait of Gibraltar and the Canary Islands (classified as low density by EMSA).

The period of the study is from July 2000 to January 2008. The number of ferries involved is 12 (none of them had two accidents), seven of them are conventional passenger ships and the other five are fast ferries.



Figures 3. Most common deficiencies.

Without evaluating the damages to property of different consideration, it is counted a total of 78 injured that had to be treated by medical services, 18 hospitalized, several minor injuries and 7 fatalities.

These are the main causes found:

— In at least half of the cases implied reference is made to the breach of any of the rules of the COLREG. In particular, two rules are always present in these failures: the rule 5: lookout, and rule 6: safe speed.

- Rule 5, lookout: given that they are fixed line and short distances ferries, it seems logical that overconfidence has a considerable weight in the absence of adequate monitoring.

- Rule 6: safe speed: excessive speed is directly related to the short time (meeting schedule).

— In addition to the references discussed in the preceding paragraph to the breach of COLREG, in seven cases it is referred in particular to inadequate speed:

- reference to high speed
- proceed to inappropriate speed
- neither of the vessels (two ferries) slacken her speed
- to reduce speed (recommendation)
- increasing in vessel speed

- inappropriate speed

- violent impact on the sea surface

— Other causes cited and that may be related to the same risk factors of accidents in this study are:

- Non-acceptance of alarm calls to mind the problems with maintaining the equipment and the overconfidence (alarms often jump without justification and make the user think they are always false alarms).

- Not to give the shelter recommended by the maritime authorities to a shoal suggests the lack of time and/or overconfidence.

- Be aware that it has bottomed out and not act as provided in Chapter 8 of SMS, emergencies (stranded) and a manifest lack of implementation of ISM Code has to relate with time constraints too.

Following those recommendations most related to this study are highlighted

— Avoid over-confidence

— Speed limit

— Encourage shipping companies to suit the working hours for crews to current regulations on special days of work, so it can be address the potential impact of fatigue.

— Insist to the owners on the need for their masters and officers to observe scrupulously the provisions contained in the International Regulations for Preventing Collisions at Sea (and it should have been added “taking into account that safety has priority over the carry out of schedules).

— Reduction of proceeding speed

— Adoption of internal rules (and it should have been added “such as the introduction of proper safety management system).

— Make the appropriate checks and regular checks to detect any anomaly or failure (and it should have been added “the guidelines set out in Chapter 10 of the ISM Code”)

— Remember to masters of vessel they have the obligation to plan the trip well in advance, taking into account the foreseeable obstacles to avoid and recommendations of the competent authorities in the field of maritime safety (Chapter 7, ISM Code).

— Raise awareness among captains of vessels that voyage planning must be done to each trip individually, even if



Figure 4. Voyage plan deficiencies

these are repetitive, avoiding routine behaviours (overconfidence, lack of time).

— Remember to classification societies and crews that examinations and maintenance of equipment and services are essential to the safety of the vessel and they should be sufficiently stringent to maintain her full operation capability (and it should have been added as outlined in Chapter 10 of ISM Code)

Finally the most outstanding conclusions of this study are summarized:

- An inefficient implementation of the ISM Code in this type of vessels and lines can generate two risk factors for accidents: the fight against time and poor maintenance of ships and equipment.
- The routine can lead to over-confidence
- The reduction in crew can generate fatigue and multifunctionality, both risk factors for accidents. Fatigue can also occur from the limits of implementation of existing legislation, at national and European level.
- The new wording of paragraph 9.2 of the Resolution MSC. 273(85) will help to take measures against the repetition in both the causes of maritime accidents and poor working conditions (the causes of maritime accidents are repeated, so as non-conformities in audits and analysis of recurring non-conformities etc.).

#### 4. Conclusions

In the view of the data presented in this article, some proposals and recommendations are made:

- Improving time management by shipping companies, with less tight schedules that allow contingency management while sailing and in port without the need to take time to recover.
- Improving management of maintenance: periodic inspections, treatment of non-conformities, software usage, contract maintenance, predictive analysis, etc.
- Strengthen the authority of the Captain. The IMO Resolution A. 443 (XI) "invited all Governments to take the necessary steps to safeguard the shipmaster in the proper discharge of his responsibilities with regard to maritime safety and the protection of the marine environment" and recognise the possible pressures that maritime trade can exert on it (time constraints, review of safety management system, maintenance reports, etc.).
- Improving control mechanism, both at company and government level. Perhaps the routine that affects these

vessels and lines, it is also affecting the maritime authorities in verifying the SMS". IMO Resolution A 1022(26) states that the effective implementation by Governments should include verification that the safety management system meets the requirements of the ISM Code, as well as verification of compliance with mandatory rules and regulations. Specifically in paragraph 2.3.3 provides guidelines for the control of the ship. It should also be noted that these vessels, which do not normally do international shipping, are less subject to external inspections.

— Maritime authorities, national and European level, should make an effort to recapture the spirit of ILO Convention 180. With regard to European legislation, policy 199/63/CE needs a revision of section 6 of clause 5 (increase working time). With regard to the Spanish national law RD 258/2002, general revision is needed (articles 15, 16, 17, 18, and additional disposal 5, etc.).

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