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Modified human factor analysis and classification system for passenger vessel accidents (HFACS-PV)

Article

MODIFIED HUMAN FACTOR ANALYSIS AND CLASIFICATION SYSTEM FOR PASSENGER VESSEL ACCIDENTS (HFACS-PV)

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ABSTRACT

With the increase in the carrying capacity of passenger vessels parallel to technological developments over the last 25 years, accidents resulting in loss of lives have increased. Thus, accidents involving passenger vessels have become a major issue of concern in the maritime industry. In this study, 70 ship collision & contact accidents involving passenger vessels between 1991 and 2015 were examined. Unlike other studies in the literature, this investigation proposes a customized Human Factors Analysis and Classification System for Passenger Vessel Accidents (HFACS-PV) to facilitate analysing the human factor in passenger vessel accidents. In addition to the core HFACS structure, an additional environment level has been defined. The violations framework has been divided into the three sub-categories of rule violations, procedure violations, and abuse of authority, instead of the two broad categories of routine and exceptional violations. Abuse of authority is an intentional violation made knowingly and wilfully, therefore, abuse of authority has been considered separately. Furthermore, minor modifications have been made to the headings under the second level of HFACS-Preconditions for Unsafe Acts for compliance with the maritime industry.

Keywords: HFACS; human factor; marine accident; accident analysis; passenger vessel

1. INTRODUCTION

An accident can be defined as pecuniary and non-pecuniary damage to a person, an object, or the environment resulting from an unintended or unexpected incident (Harrald *et al.*, 1998; Abbot and Renwick, 1999; Etman and Halawa, 2007; Grabowski *et al*., 2010; Kristiansen, 2013). Maritime accidents - accidents that occur at sea - are defined as undesired incidents resulting in death, injury, loss of vessel, damage to vessel or cargo, damage to equipment, or environmental damage (IMO, 2008).

The designs of passenger vessels have changed significantly since the 1990s. The capacities of passenger ships have increased from 500 to 6,000 persons to improve transportation efficiency and maximize profit by decreasing the unit cost of transportation (FCCA, 2014). However, this has led to increased risks: an accident often involving a passenger vessel could now have much more devastating consequences. Thus, accidents involving passenger vessels have become a major issue of concern in the maritime industry. While there are numerous accident analyses regarding cargo ships in the literature, the number of accident analyses and safety assessment studies regarding passenger vessels remains low (Lois *et al*., 2004; Kim *et al*., 2005; Antao and Soares, 2006; Dimitris and Dracos, 2008). The main reason for this is that passenger ship accidents are much less frequent than cargo ship accidents. Passenger ships represent only 8% of the world commercial fleet (Equasis, 2015). The concept of safety on passenger ships has always been at a higher level than cargo ships (IMO 1974). Hence many researchers focus on cargo vessel accidents and they are more frequent that passenger vessel accidents.

Today, there are nearly 100 proven accident investigation methods and models used in different industries (Johnson, 2003; Energy Institute, 2008; Kristiansen, 2013). Underwood and

Waterson (2013) suggested that the continuous increase in the number of analysis models and methods is a result of socio-technical systems (consisting of interactions among human, technological, and environmental elements) gradually becoming more complex as well as the changing accident causality mechanisms.

As the number of analysis models and methods has increased, studies have been carried out to group the analysis methods, to facilitate the selection and implementation of the most relevant methods to be used in accident/incident investigations. Hollnagel and Goteman (2004) evaluated a number of accident investigation methods based on their commonalities and basic principles, classifying the methods under three main groups: consecutive (sequential) models, epidemiological models, and systemic models. This classification has been recognized by many researchers, such as, Abbot and Renwick (1999), Hollnagel and Goteman (2004), Tvaryanas and Thompson (2008), Arnold (2009), Salmon *et al*. (2012) and Underwood and Waterson (2013).

2. ACCIDENT MODELS

2.1. Consecutive Models

Consecutive models suggest that the accidents occur because of discreet events happening consecutively, with many sub-causes combining to form the root cause of an accident. Therefore, recurrence of accidents can be avoided if these root causes can be eliminated (Sklet, 2004; Uğurlu *et al*., 2015a).

Domino, Fault Tree Analysis (FTA), and Event Tree Analysis are some examples of consecutive models. If an accident results from a failure of physical components or due to human error, in a simple system, these methods and models are more effective. However, they are often inadequate for defining the cause and effect relationship among management, organization, and human elements. Since they do not address these elements in sufficient detail, they are often not useful in analysing the human factor in accidents (Rathnayaka *et al.*, 2011).

2.2. Epidemiological Models

According to these models, an accident occurs as a consequence of both latent and active failures in the system (Suchman, 1960; Heinrich *et al*., 1980; Hollnagel, 2002). The formation of an accident resembles the spread of epidemic models (Suchman, 1960; Heinrich *et al*., 1980; Hollnagel, 2002 ;). Thus, the focus should be on the failure to avoid accidents (Suchman, 1960; Reason, 1990; Reason *et al*., 2006).

The most well-known epidemiological model is the Swiss Cheese Model, also known as the Reason Accident Model. Most of the other epidemiological models have been developed on the concept of this model. Human Factors Analysis and Classification System (HFACS) is also one of the methods developed using the Swiss Cheese Model. Epidemiological models allow a more detailed examination of the organizational factors and human errors that affect the occurrence of accidents that cannot be discovered during superficial examinations. Although failures in organizational or management practices represent significant potential dangers, these issues can remain latent in a system for a long time, hence, a detailed investigation is required. However, some researchers, such as, Rasmussen, (1997), Svedung and Rasmussen, (2002), and Leveson, (2001) considered the epidemiological model inadequate for examining complex accidents. To address these inadequacies, systemic techniques were developed.

2.3. Systemic Techniques

Contrary to the argument that accidents occur as a sequence of events with a cause and effect relationship, systemic techniques suggest that accidents stem from the uncontrolled relationship among the components that form a system. According to Hollnagel, (2002) accidents do not occur due to a combination of latent failures and active failures. They occur as a result of a combination of human behaviour and the use of unsafe equipment, which seems logical upon initial assessment, but in fact impairs the order of a system as it is unsafe. Simply eliminating the root causes does not prevent future accidents (Hollnagel, 2002; Ferjencik, 2011). Failures in the entire system need to be identified and holistically examined (Underwood and Waterson, 2013). While systemic techniques allow for a more detailed examination of the factors that lead to accidents, some researchers argue that it is difficult for them to be applied without sufficient technical expertise (Johansson and Lindgren, 2008; Ferjencik, 2011).

The selection of the method used in the analysis is as important as the analysis itself, as the selection affects the application of the approach to analyse the accident, which is reflected in the results. Therefore, the method should be chosen according to the complexity of the accident and the elements to be analysed (Hollnagel and Speziali, 2008; Underwood and Waterson, 2013). It is extremely important to investigate and understand the underlying human errors and organizational factors in maritime accidents, and specify measures to eliminate or minimize accidents (Hetherington *et al.,* 2006; Macrae, 2009). HFACS is a proven method customized for identifying human errors. In this method, human factors in accidents are examined systematically, and the associated causes and sub-causes are detailed. HFACS has a large field of applications (Wiegmann and Shappell, 2001; Wiegmann *et al.,* 2005; Dambier and Hinkelbein, 2006; Li and Harris, 2006; O'Connor, 2008; Rashid *et al*., 2010; Olsen, 2011; Liu *et al*., 2013). Therefore, it forms the foundation of this study.

3. HFACS LITERATURE REVIEW

Based on the Swiss cheese model, HFACS was initially developed for investigating aviation accidents in 1997 (Wiegmann and Shappell, 1997) and is a generic method for examining human error. The method can be developed and adapted to many industries (Wiegmann and Shappell, 1997; Wiegmann and Shappell, 2001). Subsequently, HFACS has been applied to many fields, such as railway transport (Reinach and Viale, 2006; Baysari *et al*., 2008), maritime transport (Celik and Cebi, 2009; Chen and Chou, 2012; Chauvin *et al*., 2013; Akyuz and Celik, 2014), healthcare (Mosaly *et al.*, 2013; Diller *et al*., 2014), and mining (Patterson and Shappell, 2010; Lenne *et al*., 2012). HFACS is a useful tool for analysing the effects of human error on devastating events, accidents, dangerous events, and deficiencies (Chauvin *et al.,* 2013; Soner *et al*., 2015).

Wiegmann and Shappell (2001) defined the main structure of HFACS in four levels: unsafe acts, preconditions for unsafe acts, unsafe supervision, and organizational influences. As HFACS's recognition and fields of application have expanded, over the course of time, many researchers from diverse industries- including Weigmann and Shappell (1997) - have modified the method for the specific industry being analysed (Dambier and Hinkelbein, 2006; Li and Harris, 2006; Tvaryanas *et al.*, 2006; Daramola, 2014). The purpose of such modifications is to make this method the most suitable to the industry, within which the human factors in accidents are analysed.

In the 2000s, the effect of human error in maritime accidents reached some 80%, prompting an increase in research in this area (Antao and Soares, 2006; Eliopoulou and Papanikolaou, 2007; Uğurlu *et al*., 2015b). Many studies in the literature, particularly in the past 15 years, have proven the success and reliability of the HFACS method in analysing human error.

Celik and Cebi (2009) examined the causes of the explosion that occurred on a dry cargo ship. In their study, they assessed the human factors identified by the HFACS method, using an analytical HFACS based on Fuzzy-Analytic Hierarchy Process (Fuzzy-AHP). The study revealed that the most significant unsafe acts result from a lack of skill, and a lack of coordination and communication among the crew. These are the most important preliminary conditions for such acts.

Schröder-Hinrichs *et al*. (2011) examined cases of fires and explosions in the engine rooms of ships using HFACS. In the study, the reports of 41 events were examined and 368 causal factors were identified. The purpose of the study was to develop a customized HFACS for revealing the effects of organizational factors and identifying the human factor in engine room fires. The sub-causes of engine room fires were identified and the HFACS-Machinery Spaces on Ships (MSS) framework was developed without any modifications being made to the main structure of HFACS. It was suggested that, rather than organizational factors, technological–environmental factors, under the category of Preconditions for Unsafe Acts, were the most significant factors, accounting for 41% of all the engine room fires.

Chauvin *et al.* (2013) used the HFACS method to examine 27 collision accident reports obtained from the Marine Accident Investigation Branch (MAIB) and Transportation Safety Board (TSB) databases. The purpose of this study was to identify the human factors in collision accidents. They expanded the main framework to develop the HFACS- Collision (Coll) structure for collision accidents. The study revealed that the most important factor in collision accidents is errors in decision-making. Furthermore, the study identified the most important causes of accidents for each category. It was highlighted that Bridge Resource Management (BRM) is very important for piloted navigation in narrow waters.

HFACS is a hybrid method, containing human factors and system approaches, as well as integrating Reason's Swiss Cheese model. This allows for accident causes to be conceptualized as interactions among active and latent system failures. In many studies since 1991, this method has been structurally modified and made suitable for various fields of application. The first category that researchers added to HFACS was environmental factors. Shappell and Wiegmann (2004) divided the environmental factors into two sub-headings, physical and technological environments, which were also included in the HFACS structure for aviation accidents. Environmental factors have been addressed under the preconditions for unsafe acts, which is the third level of HFACS (Shappell and Wiegmann, 2004). Following this study, Çelik and Çebi (2009) and Schröder-Hinrichs *et al.* (2011) also addressed environmental factors under preconditions for unsafe acts. Reinach and Viale (2006) developed a customized HFACS- Rail Road (RR) structure for railway accidents. The fifth level in the structure was defined as External Factors. This level was divided into the sub-categories of regulatory & economic control and political, social, & legal environment. Chen and Chou (2012) developed a customized HFACS-Marine Accident (MA) structure for maritime accidents and combined the preconditions level with the SHEL (Software, Hardware, Environment, and Liveware) model. They only modified the preconditions level of the HFACS main framework. The preconditions level was divided into the sub-categories of; software, hardware, condition of operators, environment, and liveware. Chauvin *et al.* (2013) defined the fifth level as the external factors in addition to the main structure of HFACS. They divided this level into two sub-categories, regulatory factors and other. As can be seen from this sample of studies, researchers have tried to develop the most suitable structures of HFACS, based on its main structure, geared towards relevant industries and the types of accidents.

4. METHOD

In this study, ~~we examined~~ collision & contact accidents involving passenger vessels between 1991 and 2015 are examined. Passenger ships - usually defined as a ship carrying more than 12 passengers - must comply with all relevant International Maritime Organisation (IMO) regulations, including those in the International Convention for the Safety of Life at Sea (SOLAS) and Load Lines Conventions (IMO, 2017). In consideration of this definition, the study was conducted to evaluate collisions & contacts involving cruise ships, ferry, ro-pax, ro-

ro ferry, passenger ships of 500 gross tonnages and more. 35 accident databases were scrutinized and a total of 70 collision & contact accident reports from 22 organizations were examined (These organisations are outlined in Table 1).

Table 1. List of maritime accident investigation organizations examined in the study

29 of the investigated accidents were of the contact type while other 41 were of the collision type. While the accidents were being investigated, officially undeclared accident data was dismissed. The accident reports examined in the study were prepared in accordance with the IMO circular of the accident investigation and contain detailed information about the accidents (formation of the accidents, causes, accident consequences, recommendations, *etc.*). In this study, the HFACS method was used to analyse the accident data, with the study consisting of 4 phases. The causes of an accident were identified and classified to determine the weight and importance of the human factor in passenger vessel accidents. Therefore, at the first phase of the study, the active causes and latent failures in collision & contact accidents of passenger vessels were identified based on the maritime accident reports. Identification and classification of accident causes have been done with a panel of three experts (decision makers). The decision makers in the study have sea experience and the necessary academic background about marine accidents, safety at sea, human factor and HFACS. As a result of detailed discussions, taking into consideration different approaches, the classification process led to the final decisions based on a consensus. Therefore, it is expected to obtain results with an acceptable level of consistency. The expert group has tried to make the most accurate classification, by reading all of the necessary accident reports. In order to facilitate this process, a systematic accident database, utilising Microsoft Excel, was created by tabulating accident data in the textual format. This database includes information on the following parameters:

- accident date,
- time of the accident,
- accident location,
- type of the accident,
- name of the vessel involved,
- flag of the vessel involved,
- technical specifications of the vessel (size, gross tonnage),
- accident severity as well as the number of deaths/injuries,
- pilot status, and
- accident causes.

In the second phase, the HFACS structures developed since 1991 were examined and checked them for compliance within the scope of our study. It was determined that the existing HFACS structures required revision to accommodate passenger vessel accidents. Therefore, ~~we~~modifications were proposed ~~modifications~~ to the main framework and sub-frameworks of HFACS, taking into account the nature of the accidents. Based on these modifications, a customized HFACS structure was developed for analysing the human factor in passenger vessel accidents: Human Factor Analysis and Classification System for Passenger Vessel Accidents (HFACS-PV). In the third phase, within the framework of HFACS-PV, the active causes and latent failures were classified. It was found that the HFACS-PV framework, by taking into consideration the passenger vessel accident reports, was compliant with collision & contact accidents. In the final stage, frequency analysis was conducted for the previously categorized active causes and latent failures. Thus, the causal factors leading to collision & contact accidents of passenger vessels and their relative priorities were revealed, taking into account the numerical data of the study. The flow chart in Figure 1 summarizes the stages of this study.

Figure 1. Flow chart of the study

5. HFACS-PV FRAMEWORK AND FOUNDATION

In the Swiss Cheese Model, which forms the foundation for the main framework of HFACS, the events causing an accident are categorized into four diverse levels and these levels are grouped under two main headings, namely, latent failures and active failures. The first three levels (preconditions for unsafe acts, unsafe supervision, and organizational influences) represent the latent failures and the last level (unsafe acts) represents the active failures. According to this model, there are latent failures behind the active failures (Reason, 1990).

According to Reason's model, accidents occur because of deficiencies in the first three levels paving the way for unsafe acts in the fourth level, *i.e*., the unsafe acts and behaviours of operators. Reason (1990) emphasized that the latent conditions in the system usually remain unnoticed until the accident occurs. He applied the Swiss Cheese model to six major events in diverse industries - the Chernobyl disaster, King's Cross fire, Herald of Free Enterprise disaster, Space Shuttle Challenger disaster, Bhopal disaster, and Three Mile Island accident -and revealed the human factors in these events (Reason, 1990). Reason suggests that people are prone to making mistakes, therefore, measures against failures must be identified and implemented. The Swiss Cheese model has been used by many researchers from many diverse industries to investigate the role of human factor in accidents (Lorenz and Ziff, 2001; Perneger, 2005; Reason *et al*., 2006; Sheridan, 2008; Underwood and Waterson, 2014).

HFACS, which is based on the Swiss Cheese model and adapted to the field used in many sectors, needed modification for the analysis of passenger ship accidents in this study. In this study, unlike other HFACS studies, it is possible to summarize the formation of ship accidents in three stages: causal factors (organizational influence, unsafe supervision and preconditions for unsafe acts), lead to root causes (unsafe acts), and accident occurrence is inevitable if root causes are combined with appropriate environmental factors.

It seems that environmental factors played an important role in the passenger ship accidents examined in many of the accident reports. The HFACS structure created in this study includes 5 levels, unlike the one developed by Shappell and Wiegmann (1996). The environment is at the forefront of the five levels related to human factors. In other words, the environment is the last stage in the formation of passenger ship accidents. In many studies (Shappell and Wiegmann, 2004; Reinach and Viale, 2006; Çelik and Çebi, 2009; Schröder-Hinrichs *et al*., 2011; Chen and Chou, 2012; Yıldırım *et al*., 2017) conducted before this research, environmental factors have been addressed under the pre-condition for unsafe act structure. In this study, it was seen that it would not be appropriate to examine environmental factors under this structure for passenger ship accident, because environmental factors are not a latent failure or a pre-condition for an unsafe act to turn into an accident. On the contrary it is an upper level necessary for an unsafe act to result in an accident. An appropriate envıronment is needed in order for an unsafe act to result in an accident. If an unsafe act does not come together with the environmental conditions necessary for accident formation, an accident will not occur. For this reason, it is not appropriate to examine environmental factors as latent failure under the categories of organizational influence or pre-condition for unsafe acts. In addition, factors under the structure of environmental factors' relation with human error are different from the factors involved in the other levels. Environmental factors include uncontrollable or partially controllable factors. When these factors are considered in the decision-making process, accidents can be prevented.

5.1. Classification of Factors within the HFACS-PV Framework

Based on the analysis and classification of human factors, the HFACS-PV model was developed for clear classification of the factors responsible for passenger vessel accidents. The proposed modifications in the main framework are marked in red font in Figure 2. The presented

HFACS-PV structure is different from other HFACS structures in the literature, taking into account the characteristics of passenger vessel accidents. The differences lie in both the main framework and the associated sub-elements. Details on the structure of the model and the distribution of the factors in accidents within this structure are provided in the following paragraphs.

Figure 2. Human Factor Analysis and Classification System for the Passenger Vessel Accidents (HFACS-PV) Model

1) Environmental Factors:

In the framework established in this study, the environmental factor is considered as a separate main level. This study indicates that if there are environmental factors influencing the occurrence of an accident, it represents the final stage of the development of a vessel accident. Even in the event that all of the necessary factors come together for the development of an accident, the accident will not occur unless a key environmental factor is present. This can be explained through the use of a simple example. The factors that played a role in the formation of a contact accident for the passenger ship The Isle of Arran, which took place on 06/02/2010, are listed as follows (MAIB, 2010):

- Environmental factors: controllable pitch propeller (CPP) malfunction (internal environment/non-conformities and failures preventing ship's motion) and restricted manoeuvring area in port (external environment/local restrictions).
- Unsafe act: unsafe speed (COLREG Rule 6) (violations/regulation violations).
- Pre-conditions for unsafe acts: master's management failures (substandard practice of team members/bridge team management/inappropriate management activities), lack of situational awareness of bridge team members (substandard condition of team members/adverse mental conditions), lack of coordination between bridge team members

(substandard practice of team members/bridge team management/lack of coordination/inboard), lack of communication between bridge and engine control room (substandard practice of team members/bridge team management/lack of communication/inboard), failure in management of emergency situations (substandard practice of team members/bridge team management/inappropriate management activities).

- Unsafe supervision: insufficient maintenance (insufficient supervision), lack of internal audit (insufficient supervision).
- Organizational influences: pre-arrival check (CPP) (organizational process/oversight/ safety assessment).

When considering this example accident, even if all the factors in the first 4 levels come together, the accident will not occur. Appropriate environmental factors are essential for the formation of the accident. Appropriate environmental factors for this accident are: restricted manoeuvring area in port and controllable pitch propeller (CPP) malfunction. An accident would not occur if there was not CPP malfunction in the port. The accident occurred due to a CPP malfunction during vessel manoeuvring in the port at unsafe speeds. CPP malfunction is an event above the unsafe speed. Similarly, the restricted manoeuvring area (port) is ranked above the unsafe speed. The reason for the CPP malfunction to cause a ship accident in the port is that the ship is navigating with unsafe speed. For this reason, it would not be suitable to examine CPP malfunction under categories of organizational influences or preconditions for unsafe acts. It would be more appropriate to examine the factors that caused the CPP malfunction under these categories in the event in the accident report. CPP malfunction is not a latent factor that plays a role in the creation of unsafe speed. However, unsafe speed is the reason behind engine failure that causes accidents within a port. It is possible to think the same way about other factors such as: rudder failure, blackout of the ship and bow thruster failure, which is contained within the category of internal environment as it prevents the ships movement directly. Factors such as narrow waterways, channels and heavy traffic are also placed under external environment/local restrictions. Hence, it would be more appropriate for all of these factors to be placed in the environmental factors framework. It would be more appropriate to place the factors that cause these factors (engine malfunction, propeller failure, *etc*.) under latent factors, in the event in the accident report.

Another example of a marine accident is the collision between the Cotai Strip Expo and the Xin Fei. The factors that played a role in the formation of the collision accident between these two vessels, on 01/7/2008, are identified as follows (MARDEP, 2011):

- Environmental factors: engine malfunction (internal environment/non-conformities and failures preventing ship's motion) and narrow waterway (external environment/local restrictions).
- Unsafe act: unsafe speed (COLREG Rule 6) (violations/regulation violations), inappropriate collision avoidance manoeuvre (COLREG Rule 8) (violations/regulation violations), improper manoeuvring in Traffic Separation Scheme (TSS) (COLREG Rule 10) (violations/regulation violations), violation of transition rule in overtaking situation (COLREG Rule 13) (violations/regulation violations) and improper lookout (COLREG Rule 5) (violations/regulation violations).
- Pre-conditions for unsafe acts: lack of ship-ship communication (substandard practices of team members/BTM/lack of communication).
- Unsafe supervision: inadequate safe distance between ships (planned inappropriate operations).
- Organizational influences: master unfamiliar with the bridge navigation equipment (resource management/human resources/lack of training & familiarization/vessel).

Appropriate environmental factors for this accident are narrow waterways (restricted manoeuvring area) and engine malfunction. An accident would not occur if there was not an engine failure in the narrow waterway. The accident occurred due to engine failure when the ship was navigating in the narrow waterway with unsafe speed and violation of inappropriate collision avoidance maneuver (COLREG Rule 8), improper maneuver in TSS (COLREG Rule 10), violation of transition rule in overtaking situation (COLREG Rule 13) and improper lookout. Engine failure is a phenomenon above the unsafe speed and other unsafe acts. Similarly, the restricted manoeuvring area (narrow waterway) is above the unsafe speed and other unsafe acts. Violations of COLREG Rule 5, 8, 10 and 13 were not caused by engine malfunction, these violations occurred due to lack of proper manoeuvring area between vessels in order to avoid collision (unsafe supervision) and lack of communication between vessels (pre-condition for unsafe acts).

In addition, the characteristics of environmental factors are not the same as the ones of the factors under the preconditions for unsafe acts level. For example, poor visibility due to dense fog and risk of intensive ship traffic will be confronted as a dominant human factor if classified under the preconditions for unsafe acts. However, these factors cannot be prevented by the ship's personnel. For this reason, they are characteristically different from other factors, as it may not be possible to prevent busy traffic or to prevent dense fog. On the other hand, factors under preconditions for unsafe acts such as lack of attention, stress and lack of situational awareness are completely different from those mentioned above. For this reason, it would not be appropriate to evaluate all such factors under the same category. Therefore, environmental factors are considered as a separate level and divided into two subcategories: internal and external.

a) Internal environment:

These include factors related to the ship, factors affecting ship movement and partially controlled by operators. For this study, these non-conformities have been examined under the internal environment subcategory with the name of "non-conformities and failures preventing ship's motion". They are non-conformities at a higher level of unsafe actions. These non-conformities include factors that play a role in the accidental conclusion of unsafe actions. Figure 3 shows the general structure and the factors examined within this category.

Figure 3. Internal environment

b) External environment:

This includes natural conditions and non-vessel factors that neither relate to the structure of the vessel nor stem from human contribution or intervention. We further divided this categoryThis category is further divided into two sub-categories: weather conditions and locational restrictions (Figure 4). The category of weather conditions was examined under two sub-headings: conditions impairing visibility and conditions preventing vessel motion. This division is aimed at correctly classifying the factors with different characteristics. It allows the effects of weather and sea conditions and the effects of the locational restrictions on maritime accidents to be easily distinguished.

Figure 4. External environment

The example factors given under the category headings in Figure 3 and Figure 4 belong to the collision & contact accidents investigated in the study. However, these examples do not cover all the factors to be examined under the category. When different accidents are examined similar factors such as, non-conformities that prevent the ship's motion, local restrictions, and weather and sea conditions will be examined.

2) Organizational influences:

- Organizational influence is the first step in the formation of unsafe acts. During the process of classification of the factors obtained from the research on accidents, it was found that the organizational influences level developed by Shappell and Wiegmann (1996) was also compliant with the maritime industry (Celik and Cebi, 2009; Xi *et al.*, 2009; Xi *et al*., 2010; Chen and Chou, 2012; Chauvin *et a*l., 2013). Therefore, this was divided into three sub-categories: resource management, organizational climate, and organizational process, as conducted in other studies in the literature (Wiegmann and Shappell, 1997; Rothblum, 2000; Chauvin *et al*., 2013).

a) Resource management:

This was further divided into two sub-categories: human resource and equipment/facility resource, as shown in Figure 5. This category includes human error by organizations operating the vessel and the ports, with regard to resource management. Factors such as deficiencies in training and familiarity of the crew, short-staffed crew, and inexperienced crew were examined under the category of human resources. On the other hand, factors related to deficiencies of equipment and facilities, insufficient equipment, inappropriate equipment, and inappropriate ergonomic design were also examined under the category of "equipment and facility resource".

Figure 5. Resource management

b) Organizational climate:

This includes deficiencies and non-conformity in the organizational structure, policies, and culture of the employing organization that affect the performances of those working on board, as shown in Figure 6. For instance, if a company does not have a zero alcohol and drug policy, it will be partly liable if an officer in charge causes an accident whilst under the influence of alcohol or drugs. Similarly, if there is no organizational culture that encourages an atmosphere of communication and coordination among the team members, the company will be partially responsible for the lack of communication between the master and the officers. Consequently, if the administrative structure of an organization was not well formed from the start, leading to inefficiency and disorder, it is fair to assume that there would be no atmosphere of safety and trust in that organization (Wiegmann *et al*., 2005; Baber, 2007; Chen and Chou, 2012).

Accident investigators particularly address deficiencies and non-conformity in the reports on aviation accidents. However, detailed information regarding deficiencies and non-conformity is limited or does not exist within the reports of the passenger accidents in this study. Therefore, it is not possible to assess this category effectively, even if it is included in the HFACS-PV structure. When other studies were examined in the literature, very few factors regarding the organizational climate were identified (Schröder-Hinrichs *et al*., 2011; Chen and Chou, 2012; Chauvin *et al.*, 2013; Chen *et al*., 2013). Declaring such non-conformities can lead to commercial concerns or loss of prestige for companies. Hence, non-conformities under this category represent sensitive information that companies may be concerned about, making such non-conformities difficult to identify in marine accident reports.

Figure 6. Organizational climate

c) Organizational process:

This includes the deficiencies in the management of the organization, the deficiencies in safety assessments regarding the legal processes (work/rest hours, time pressure, motivation, shift orders, *etc.*) and their reviews (risk analysis, risk management, *etc.*), and any non-conformities (Shappell and Wiegmann, 2000). Within the framework developed by Shappell and Wiegman (2000), the procedure heading was changed to legal deficiencies, and these legal deficiencies were examined under two sub-categories, namely, procedure-based deficiencies and legislation-based deficiencies as demonstrated by Figure 7. Factors such as mistakes in the process of planning the manoeuvring operation, negligently prepared manoeuvre or navigation plans, lack of risk assessment procedures, and neglected risk assessments prior to operations are examined under the organizational process.

Figure 7. Organizational process

3) Unsafe supervision:

Unsafe supervision is the second step in the formation of unsafe acts. There are three sub-categories at this level: insufficient supervision, planned inappropriate operations, and failure to correct a known problem (Figure 8). In the core HFACS structure of Shappell and Wiegmann (2000), a fourth sub-category of supervisory violations was also included. However, considering the causal factors examined under this structure (Wiegmann and Shappell, 2001; Shappell and Wiegmann, 2004), it would be more appropriate to examine these factors for passenger vessels within the violations and substandard conditions of team members. Therefore, the sub-category of supervisory violations was removed from the HFACS-PV structure. Factors regarding matters such as the failure to carry out routine tests and checks, deficiencies in implementation of the planned maintenance system, inappropriately planned operations (navigation plan, number of lookouts on shift, *etc.*), and failure to correct a previously identified problem (sailing with a malfunctioning radar, *etc.*) are included under the Unsafe Supervision category.

Figure 8. Unsafe supervision

4) Preconditions for unsafe acts:

The preconditions for the unsafe acts level that prepares unsafe actions, which is also located at the core of HFACS structure includes factors that set the ground for unsafe acts of the operators. It was emphasized by Shappell and Wiegmann (2000), among others, that this frame is important for accident occurrence. Shappell and Wiegmann (2000) emphasized that it is insufficient to only focus on unsafe actions to understand the accident occurrence and prevent accidents; only focusing on unsafe actions to prevent accidents, is similar to focusing on health symptoms, such as high fever, to prevent the disease. Pre-conditions of unsafe acts are the last level playing a role in the formation of unsafe acts. Unlike Shappell and Wiegmann's (2000) and other studies in the literature (Celik and Cebi, 2009; Xi *et al*., 2009; Chen and Chou, 2012; Chauvin *et al*., 2013; Chen *et al.*, 2013) these factors, which set the ground for the unsafe acts of the operators, were divided into two subcategories; malfunctions in the electronic navigation aids and substandard team members.

a) Substandard team members:

This category is divided into two sub categories; substandard conditions of team members and substandard practices of team members. The reason for such a division is due to the fact that vessel management (administration) is carried out by a team. From the master to the helmsman (including the pilot) on the bridge and from the chief engineer to the oiler in the engine room, everyone is a member of the team. Navigation or manoeuvre can only be safely achieved when there is accord and communication among the team members. Therefore, analysis of an accident should focus on the substandard conditions and practices of all the team members (not just the master) on board at the time of the accident.

i) Substandard condition of team members:

This category includes adverse conditions and limitations affecting both mentally and physically those involved in manoeuvring and navigating the vessel, including the pilot. This category is demonstrated in Figure 9. Adverse mental conditions include factors such as mental fatigue, stress, lack of attention, lack of situational awareness, excessive self-confidence, and recklessness. Adverse physical conditions include factors such as sickness (flu, cold, *etc.*), physical fatigue, and sleeplessness. These conditions place strain on the physical and mental capacity of a person. An example of this is night lookouts; the lookout efficiency of the crew decreases at night since there is a lack of sufficient light. One requires more effort to perform efficiently than they would during the day. Therefore, lookout on the night shift is one of the conditions for unsafe actions.

Figure 9. Substandard conditions of team members

ii) Substandard practices of team members:

This category, which is included in the core structure of the HFACS as substandard practices of operators, was applied to passenger vessel accidents without any change in the structure (Shappel and Wiegmann, 2000; Wiegmann *et al.*, 2005). It is worth noting that the framework was named to include the substandard practices of all the team members, as shown in Figure 10. Accordingly, the substandard practices of the team members were divided into two sub-categories: readiness for operation and bridge team management.

Readiness for Operation: This sub-category is very important for completing a task safely and appropriately. Conditions that affect readiness for operation also pave the way for unsafe actions. Therefore, the readiness for operation takes into account factors that affect the readiness of the team members in physical, mental, and psychological terms. Some of these factors include being under the influence of drugs, being intoxicated, and violating work and rest hours.

Bridge Team Management: As mentioned before, the management of a vessel is teamwork. The fundamental components of efficient team management are communication, coordination, and management activities. Therefore, the components in team management were divided into three sub-categories in this study: inappropriate management activities, lack of communication, and lack of coordination. The deficiencies, failures, and non-conformity in these sub-categories trigger unsafe actions directly. Substandard acts within bridge team management include factors such as lack of authority, deficiency in management, loose management, lack of communication, and lack of coordination.

Figure 10. Substandard practices of team members

b) Malfunctions in the electronic navigation aids:

These are preconditions that play a role in the emergence of unsafe actions. When the structure and the formation of these malfunctions are taken into consideration, examination of the factors under organizational influence or unsafe supervision levels is not likely to be appropriate. Because these malfunctions are emerging due to the factors under the unsafe supervision or organizational influences level. This is because these malfunctions emerge due to factors under the unsafe supervision or organizational influence levels. For this reason, it would be more appropriate to examine it at the last stage before the unsafe action takes place. The general structure of the framework and factors examined are shown in Figure 11.

Figure 11. Malfunctions in the electronic navigation aids

5) Unsafe Acts:

This includes inappropriate acts and the misconduct of team members. They are the triggering acts at the last level that cause an accident. According to the HFACS structure developed by Wiegmann and Shappell (1997), Unsafe Acts can be divided into two sub-categories: errors and violations resulting in accidents. Errors include acts performed unintentionally during otherwise proper conduct, which prevent successful performance. Violations include improper acts performed intentionally, *i.e*., violation of the rules and regulations (Shappell and Wiegmann, 2000; Wiegmann *et al*., 2005). The accident reports examined in this study revealed that it is appropriate for errors and violations to be used for the classification of the human factors in accidents. Therefore, errors and violations are included in the HFAC-PV structure. However, violations were not categorized as "routine" or "exceptional," as defined by Wiegmann and Shappell (1997). Violations were divided into three categories: legal arrangement violations, procedure violations, and abuse of authority, as a classification of the violations on the basis of legal arrangements and procedures would better explain the seriousness and legal aspect of the action performed. Legal arrangement violations are the violations of international/national rules that must be complied with. Procedure violations are the violations of written directives that vary according to the structure of the organization operating the vessel and are usually formulated based on experiences.

The accident investigation study that was carried out revealed that accidents caused by violations occur differently due to abuse of authority. For instance, a radar device has many safety alarms (such as, destination alarm, electronic bearing, range marker alarms, *etc*.), subsequently, these alarms sound frequently during shifts on-board and may disturb some of the officers and masters in charge. Hence, these alarms are often switched off. Switching off these alarms increases the burden of lookout on shift workers. This, when combined with the other factors, can lead to an accident. On the other hand, when the officers or masters in charge - disturbed by the radio sounds on the bridge - decrease the volume of the radio, it is an abuse that leads to auditory lookout violation. Therefore, abuse of authority was also examined within the category of violations in the HFACS-PV structure.

a) Errors:

According to studies in the literature, errors include those of skill (such as failure to operate the machine control panel effectively), decision-making (such as attempting to avoid collision & contact by manoeuvring in the wrong direction) and perception (such as incorrect interpretation of the effects of the wind and current on the vessel) (Shappell and Wiegmann, 2000; Chauvin *et al.*, 2013; Chen *et al*., 2013). The Error framework is demonstrated in Figure 12.

Skill-based errors are unintentional errors stemming from lack of knowledge and experience. Decision-based errors are those that occur as a result of incorrect intentional choices and acts. Decision-based errors are also referred to as "honest mistakes" in the literature (Shappell and Wiegmann, 2000; Baber, 2007). Perceptual errors are errors that occur due to incorrect perception or interpretation of quantities such as distance, altitude, or speed.

Figure 12. Errors

b) Violations:

Violations were examined under three sub-categories: violation of legal arrangements (regulations), violation of procedures, and abuse of authority, as shown in Figure 13.

Violations of legal arrangements (regulations): These include factors regarding intentional neglect or non-execution of the legal arrangements published by the IMO, flag states, or competent authorities. Acting contrary to the International Regulations for Preventing Collisions at Sea (COLREG), non-compliance with the shift arrangements stipulated by the International Convention on Standards of Training, Certification and Watch keeping for Seafarers (STCW), and non-compliance with the work–rest hours under the Maritime Labour Convention (MLC) are typical examples of legal arrangement violations.

Procedure violations: These include violating the arrangements prepared by vessel operators, particularly by maritime companies on the basis of national and international rules and experience. These procedures are not as strong as regulations in legal terms. Violations of procedures such as navigation safety, anchoring, berthing, and other manoeuvring and shift handover procedures are some examples of these violations.

Abuse of authority: This is an intentional violation made knowingly and wilfully. It is improper use of a position of influence, power or authority knowingly and wilfully (UN, 2008). For instance, in the Costa Concordia accident (IMO, 2016), the deviation from the route in order for the passengers to see the islands more closely was not a procedure violation or regulation violation since the master of the ship is vested with the legal authority to deviate from the route. However, the reason for the deviation was not based on the safety of the vessel or the passengers and that navigation safety was violated for the entertainment of the passengers. This signifies that the master abused his authority to deviate from the route.

Figure 13. Violations

6. RESULTS AND DISCUSSION

In this study it has been found appropriate to consider environmental factors as a separate main level in the formation of ship accidents. Factors that fall under the context of environmental factors are not a latent failure or unsafe acts, but rather an upper level that leads to accidental consequences of unsafe acts. For this reason it would be appropriate to consider it as the final stage in the formation of accidents. In this study, 517 factors have been identified by examining 70 collision & contact accidents that occurred on passenger vessels. Frequency and percentage values were calculated according to 517 factors. The HFACS-PV model for collision & contact accidents together with the identified frequency and percentage values of each category or sub-category is shown in Table 2.

Table 2. The frequency of the factors causing collision & contact accidents

Environmental factors have been found to be 19.92 % effective in the formation of collision & contact accidents involving passenger ships. This result is in line with the ones in the studies for other vessel types in the literature (Xi *et al*., 2009; Chen and Chou, 2012; Chauvin *et al*., 2013; Chen *et al.*, 2013). The most effective among environmental factors is local restrictions with 11.41%. Local restrictions are among the most significant impediments on vessel manoeuvring. It is not possible to eliminate local restrictions, but these risks can be kept under control by assigning experienced team members who have worked in the area for a sufficient period of time. Therefore, companies operating passenger vessels should give importance to experience in navigation during the selection and assignment of crew members (including the master).

Another important cause within the environmental factors is unfavourable weather and sea conditions. It was found that unfavourable weather and sea conditions account for 30 accidents that passenger vessels were involved in, with 12 out of 30 accidents occurred in strong winds. The root cause of this is the incorrect interpretation of the effect of the wind on the vessel by team members. It is not possible to eliminate unfavourable weather and sea conditions.

However, in order to avoid accidents, team members should know the vessel well and be able to correctly interpret the effects of the weather and sea conditions in vessel manoeuvring. Therefore, team members meant to carry out the management of the vessel should be assigned based on professional experience and passenger vessel experience.

While the non-conformities and failures preventing the ship's motion responsible for accidents (16 accidents) were sudden, uncontrolled events and human error also played a part in these accidents. It is possible to avoid failures with planned maintenance, conscious operation (within the guidelines and operational limits), and timely supervision and checks.

Unsafe acts are the most significant in the occurrence of collision & contact accidents with 35.01%. Errors and violations under this category have a frequency of 17.61% and 17.41% respectively. The most important sub-category that contributes to collision & contact accidents within the violations category is the regulation violations (14.7%). The most common violations under the regulation violations are COLREG Rule 5 (inappropriate lookout) and COLREG Rule 6 (unsafe speed). Among the collision & contact accidents examined in this study, violations of COLREG Rule 6 were found in 25 accidents and violations of COLREG Rule 5 were found in 24 accidents. The results of this stage of the study show consistency with the results of some accident analysis studies in the literature. In other studies carried out by Chauvin *et al*., (2013), Uğurlu *et al*., (2013), and Uğurlu *et al.*, (2015b) for different vessel types), the emphasis was laid on the importance of COLREG Rule 6 and COLREG Rule 5 in collision & contact accidents. Among the errors, the most important sub-category was found to be bridge team management errors with 11.8%. The most significant bridge team management errors include lack of a chain of command among the team members, lack of communication and coordination, and lack of team spirit. If the master of the vessel is a very competent team manager, the team members embrace their jobs and work in harmony with fellow team members, making vessel operations safer.

Preconditions for unsafe acts are the second most significant, with a 30.37%. The most important cause under the preconditions for unsafe acts level is substandard bridge team management practices (11.8%). The most significant problems found in substandard bridge team management practices are lack of ship-to-ship communication (10 accidents) and a lack of master–officer-in-charge coordination (11 accidents). Unsafe acts occur due to deficiencies in the first three levels (organizational influences, unsafe supervision, and preconditions for unsafe acts), as suggested in the Swiss Cheese Model. Similar to many other studies carried out previously by Celik and Cebi (2009) and Chauvin *et al.*, (2013), this study also revealed that the most important among the first three levels is preconditions for unsafe acts. Therefore, in order to avoid or minimize accidents, the focus should be on attempting to avoid the occurrence of preconditions for unsafe acts. In doing so, it will be possible to avoid the unsafe acts of team members to some extent. Among the preconditions for unsafe acts, one cause of accident specific to passenger vessels is the excessive workload introduced by Pilotage Exemption Certificate (PEC). In order to avoid passenger vessel accidents, it is extremely important that companies give particular attention to experience in navigation during the assignment of masters. However, exempting the vessel from pilot services on the basis of the master's experience and a pilotage exemption certificate would increase the risk of an accident due to the excessive workload on the master, because a master holding a PEC would have to act as a master and a pilot at the same time in the area. In this study, three accidents were found to have stemmed from excessive workload on the master due to pilotage exemption. Therefore, an important step to avoid the occurrence of such accidents would be to make pilotage compulsory in relevant areas.

Organizational influences have 11.28% in the occurrence of collision & contact accidents of passenger vessels. The most important subcategory in this level is human resources management, with 3.9%. Non-conformities in the human resource management of companies operating a vessel affect the occurrence of accidents. In order to avoid such accidents, companies should determine their principles for personnel selection and assignment on the basis of professional experience and culture of safety. Even the slightest inappropriate assignment (lack of training, familiarity, and experience) in the upper team (master, chief engineer, and chiefs) may affect all vessel operations and threaten the safety of the vessel and its passengers. Human resources management is extremely important, not only in terms of selection and assignment but also in terms of maintaining safety. Another important sub-category examined under the organizational influences level is inappropriate ergonomic design. Design flaws were found in nine collision & contact accidents. There are only a limited number of studies in the literature that highlight the effects of design flaws in vessel accidents (Chauvin *et al.,* 2013; Han and Ding, 2013; Akhtar and Utne, 2014). Therefore, it is recommended to take into account the deficiencies associated with design flaws to avoid collision & contact accidents. Design flaws causing collision & contact accidents of passenger vessels were found to be designs limiting visibility, overhead lighting impairing visibility, bridge sound insulation inhibiting auditory lookout, bridge ergonomic design flaws, wing wheel panel ergonomic design flaws, and bridge manoeuvre console ergonomic design flaws. The bridge's design and ergonomics are extremely important for maintaining the safety of the bridge navigation shift. Design flaws are not factors that can be corrected by the bridge team. The chart console, electronic navigation devices, and communication devices should be placed on the bridge in such a manner that they do not inhibit visual lookout and can be used effectively, even when there is only one watch-keeper on the bridge. Therefore, ergonomics should be taken into account during the construction and maintenance of vessels in the shipyard. The effects of the organizational environment within the category of organizational influences (which is very important in aviation accidents) on the collision & contact accidents of passenger vessels could not be identified completely. This is because this heading was not investigated in detail in the existing accident reports for passenger vessels. Therefore, investigative authorities should look into the organizational climate and safety culture of companies in charge of operating a vessel involved in an accident.

The category of unsafe supervision has 3.48% in passenger vessel accidents. The most important within this category is planned inappropriate operations (2.32%). The most important planned inappropriate operations are inappropriate navigation plan (five accidents) and lack of lookout (four accidents).

7. CONCLUSION

In this study, unlike other studies in the literature, a customized HFACS structure for the analysis of human factor in passenger ship accidents has been presented. In addition to the traditional, core HFACS structure, the biggest change in the structure is the addition of environmental factors as the fifth and final level to the main framework. Similarly, the HFACS structure has been aligned with the maritime sector by making changes associated with the unsafe acts and the corresponding preconditions. Thus, a modified HFACS-PV structure has been developed for analysing passenger vessels' collision & contacts.

Active causes and latent failures were classified under the structure of HFACS-PV. It was found that the HFACS-PV framework was compliant with collision & contact accidents, taking into consideration the passenger vessel accident reports. In the final stage, a frequency analysis was conducted for the previously categorized active causes and latent failures. Thus, the causal factors leading to collision & contact accidents of passenger vessels and their relative priorities were revealed, taking into account the numeric data of the study. In addition, recommendations have been made for the prevention of accidents. The results of this study are realistic, and expected to be useful for preventing ship accidents. The HFACS-PV structure makes it much easier to understand and interpret the occurrence of vessel accidents. In future studies, the compatibility of this structure with accidents in passenger vessels and ones in other vessel types, can be analysed.

8. ACKNOWLEDGEMENTS

This study has been carried out in Turkey and United Kingdom with the cooperation of Karadeniz Technical University and Liverpool John Moores University under the titled of research "Lessons learned from last twenty years of passenger ship accidents and accident-free future". The study was supported by TUBITAK (The Scientific and Technological Research Council of Turkey/2219 scientific research support program). The authors would like to thank TUBITAK, who financially supported the study.

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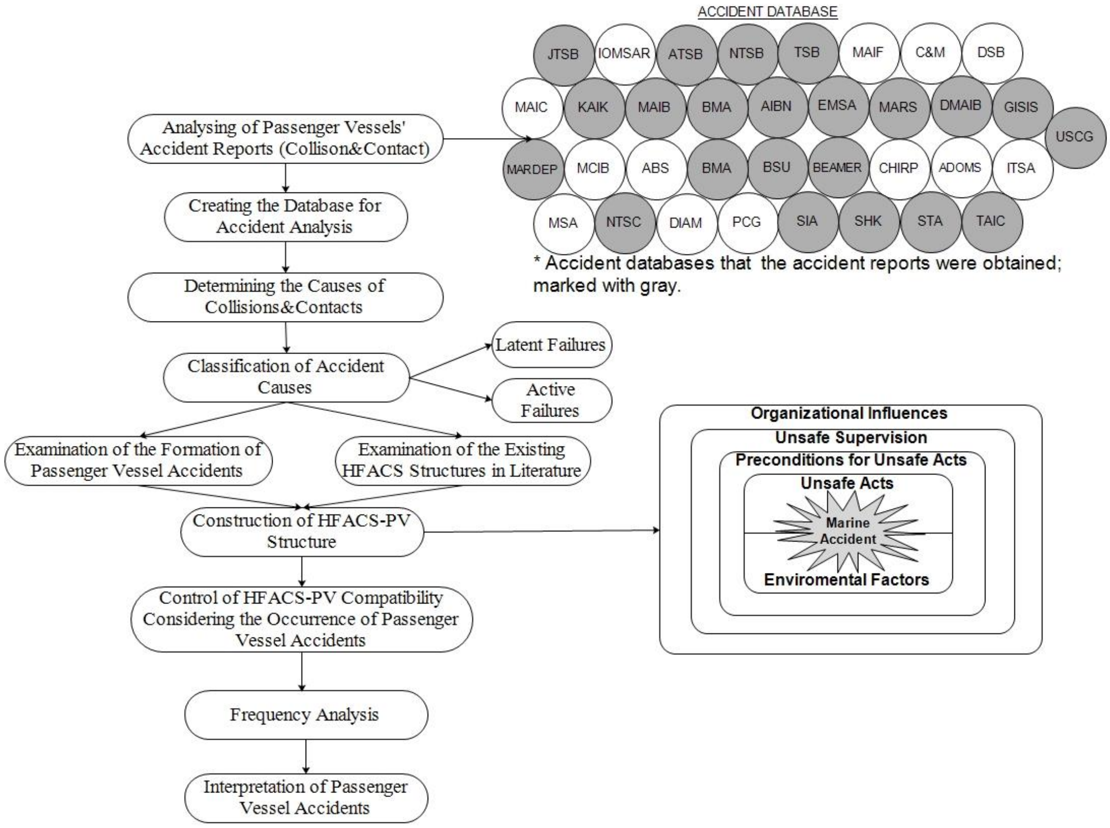

Figure 1. Flow chart of the study

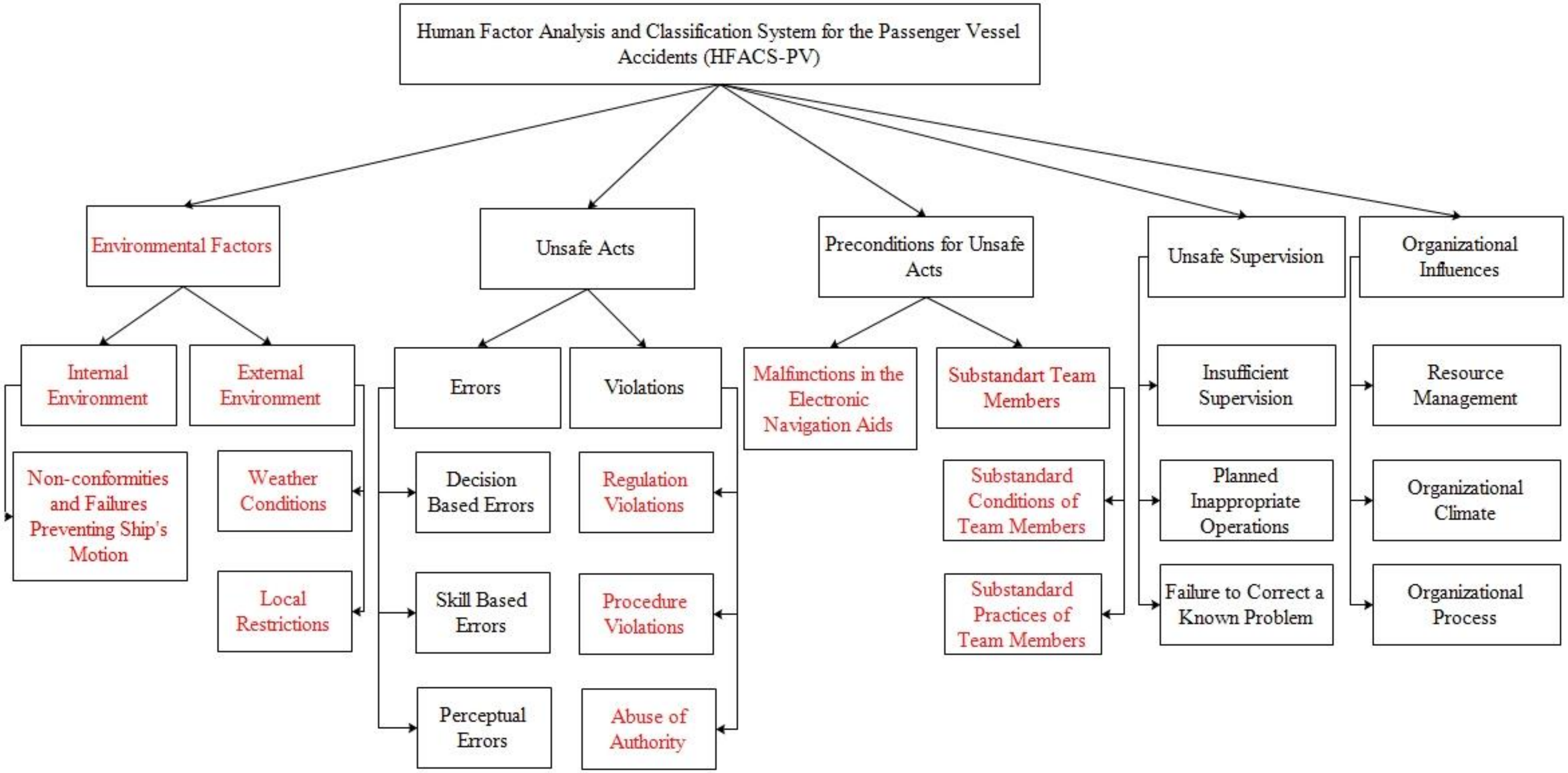

Figure 2. Human Factor Analysis and Classification System for the Passenger Vessel Accidents (HFACS-PV) Model

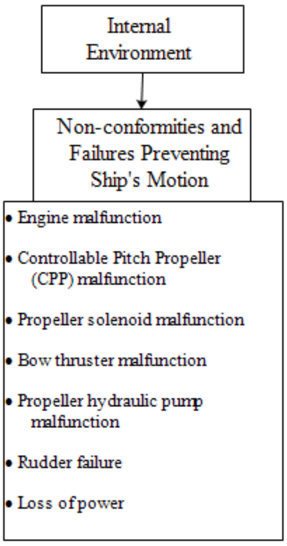

Figure 3. Internal environment

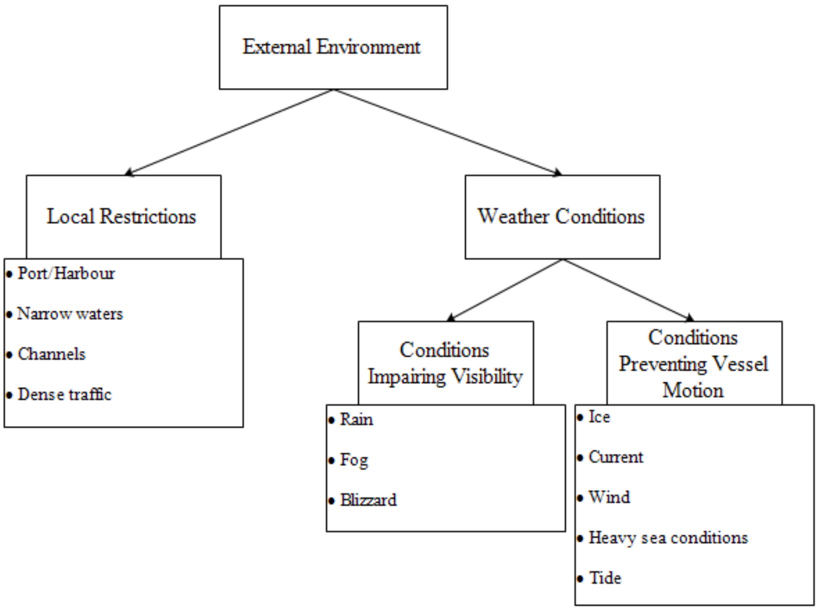

Figure 4. External environment

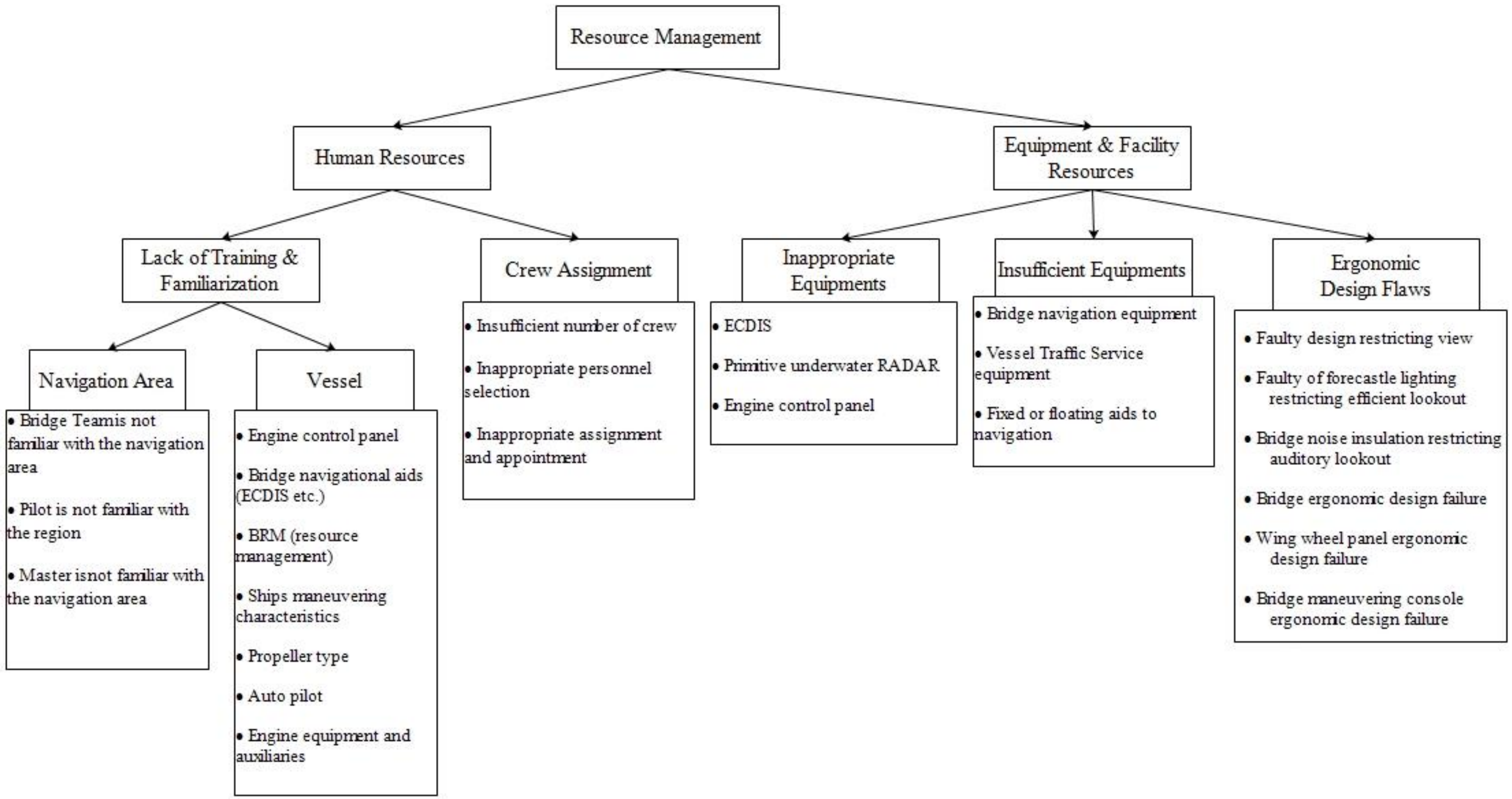

Figure 5. Resource management

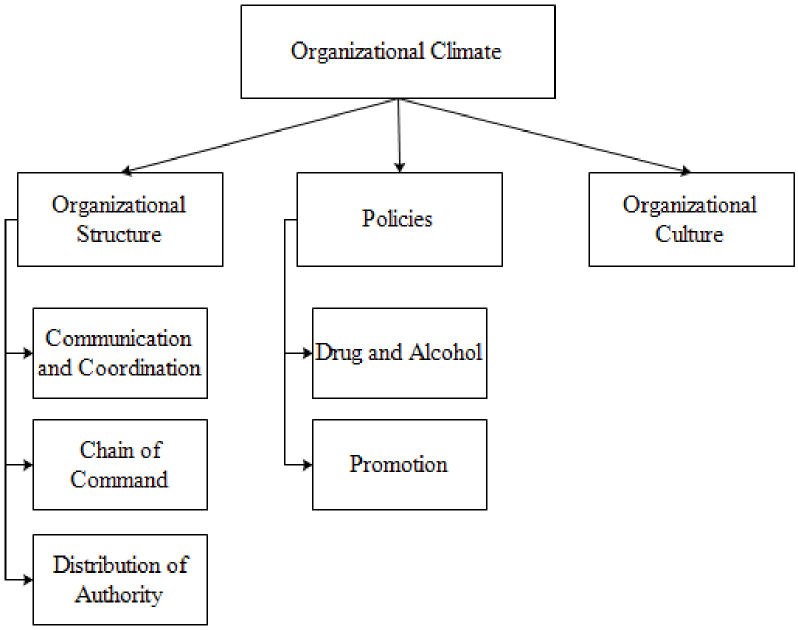

Figure 6. Organizational climate

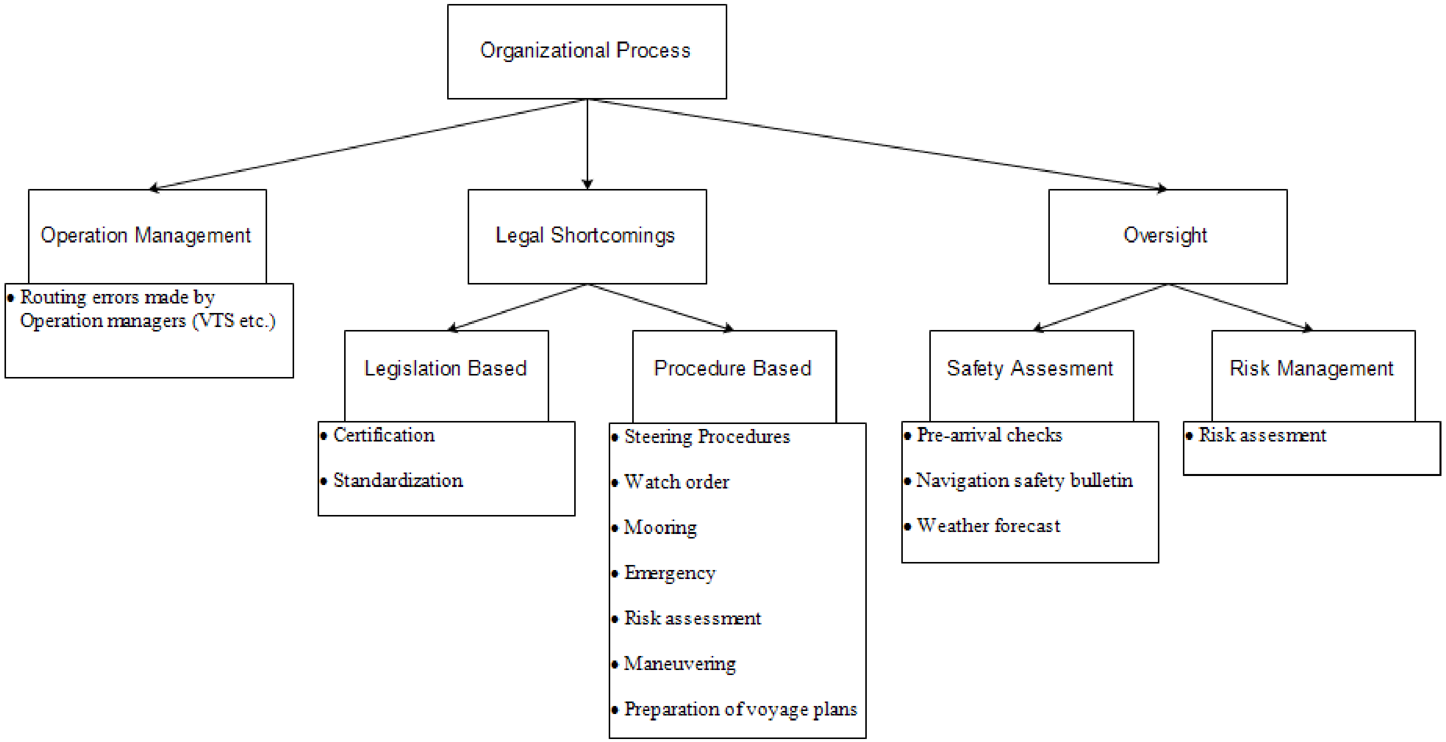

Figure 7. Organizational process

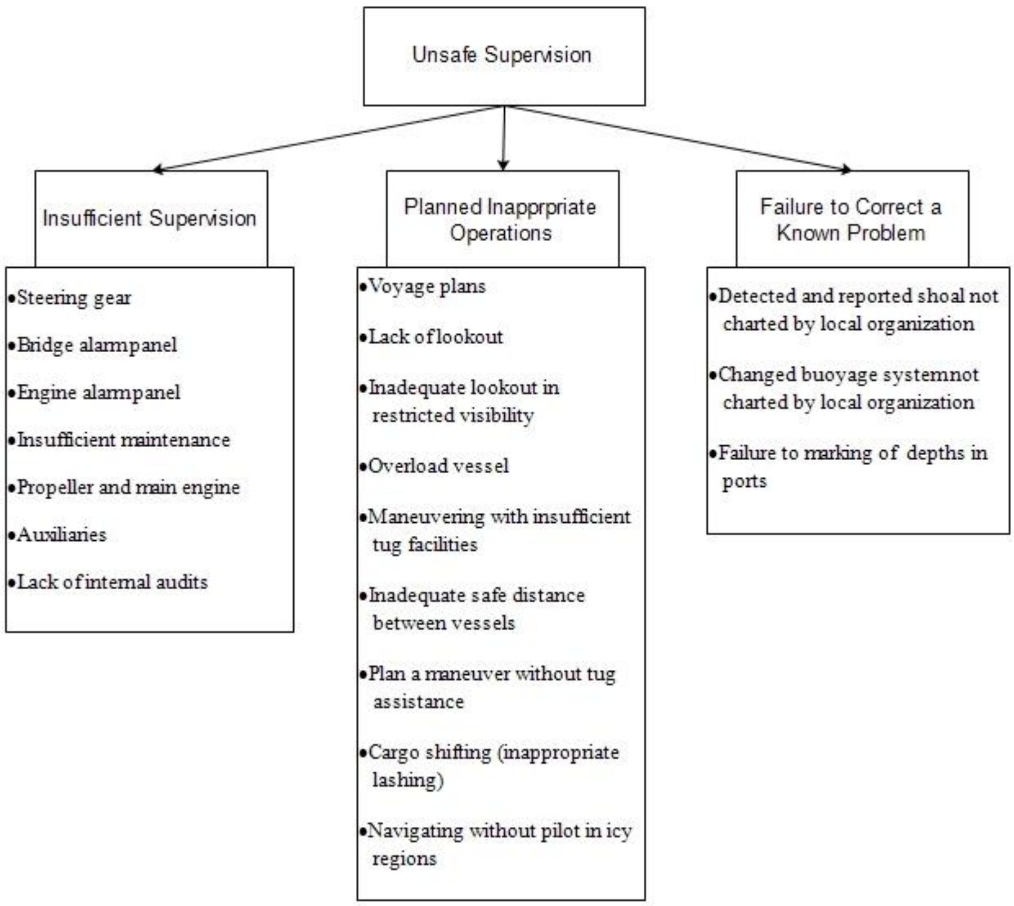

Figure 8. Unsafe supervision

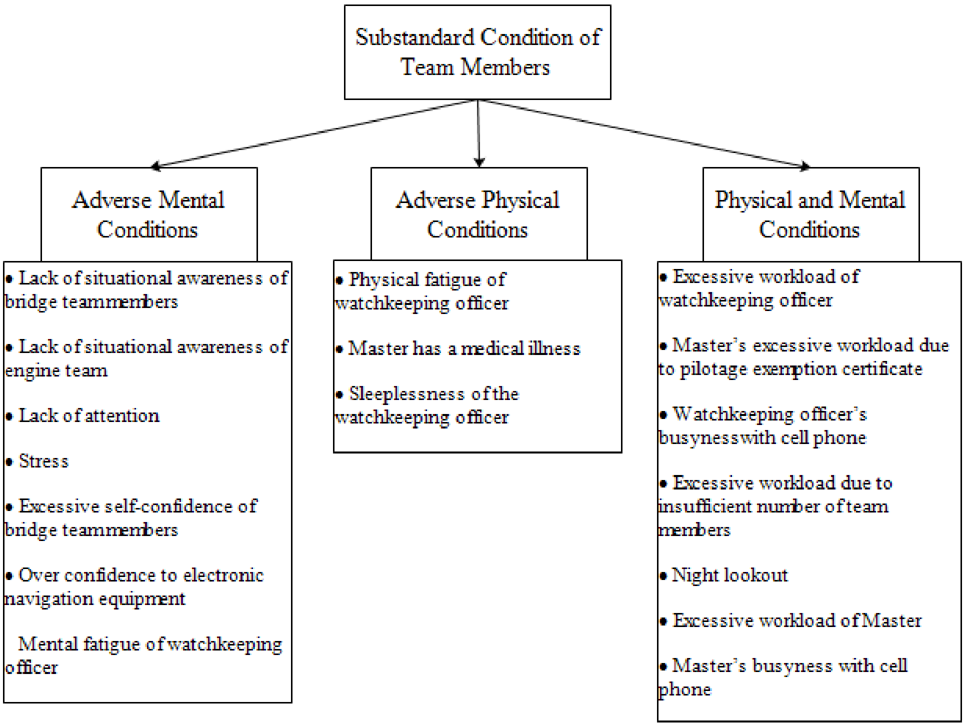

Figure 9. Substandard conditions of team members

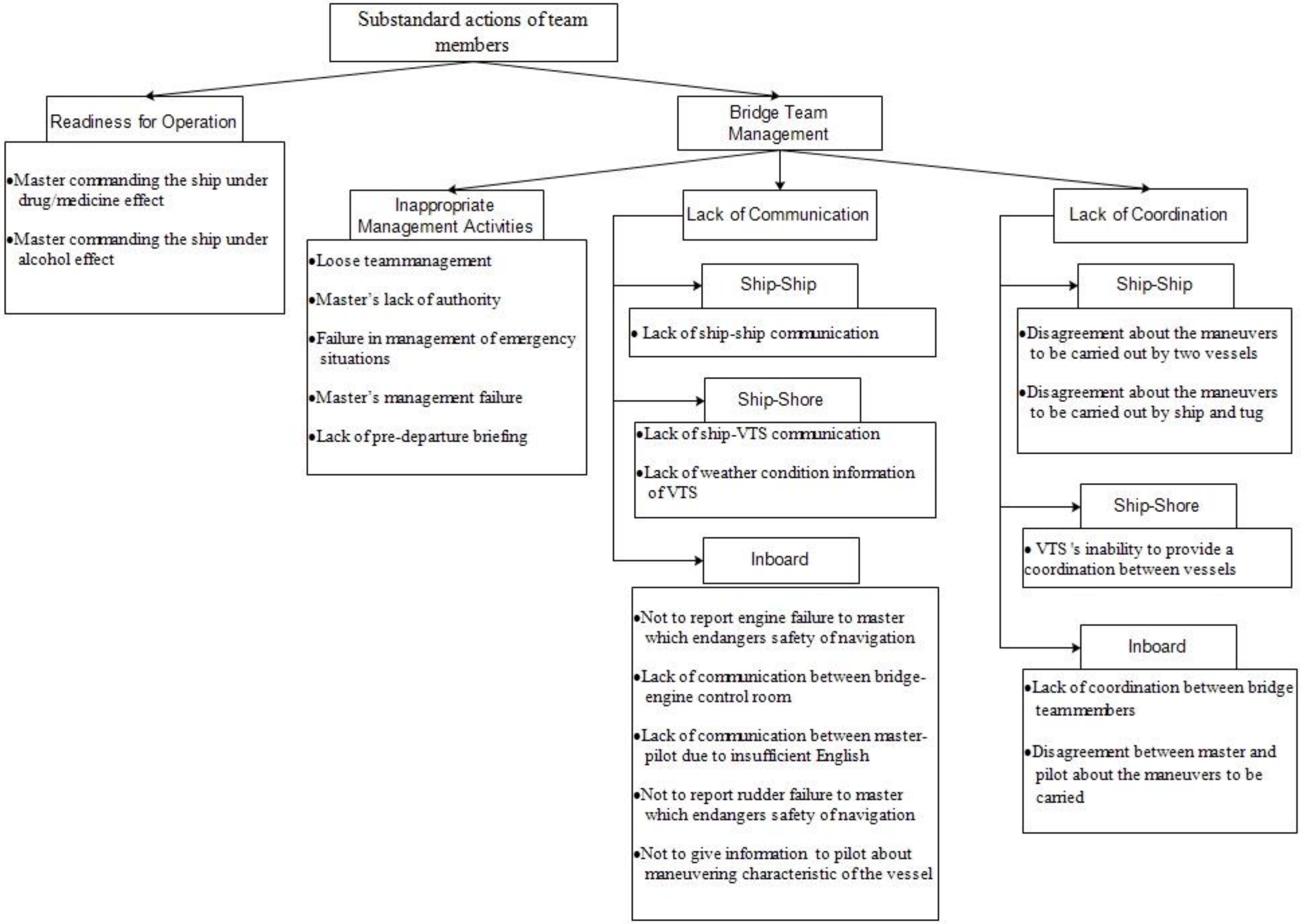

Figure 10. Substandard practices of team members

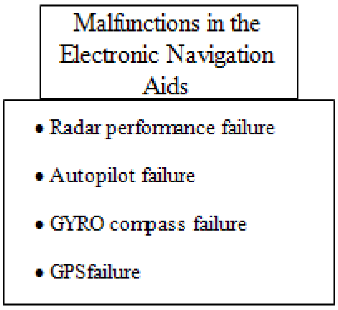

Figure 11. Malfunctions in the electronical navigation aids

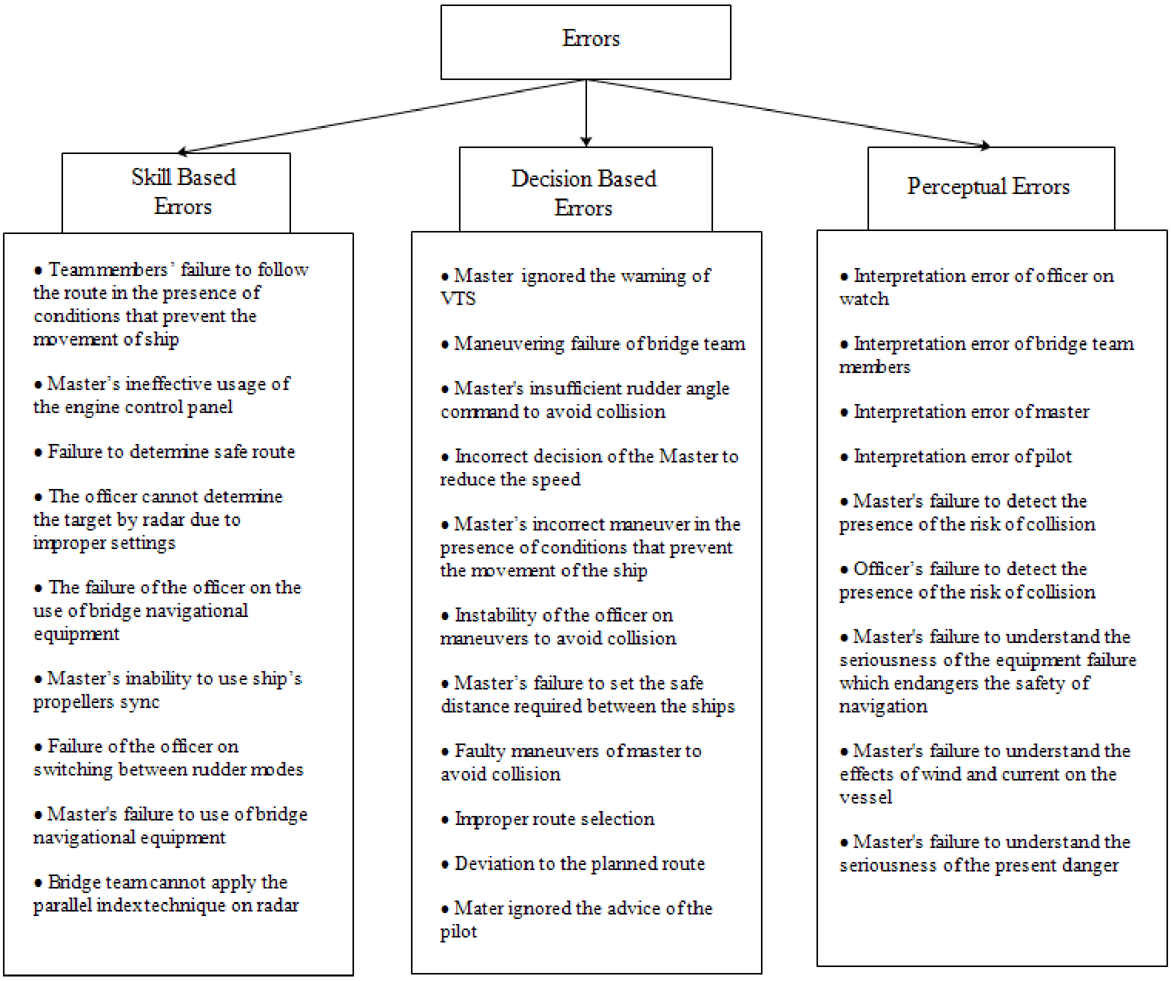

Figure 12. Errors

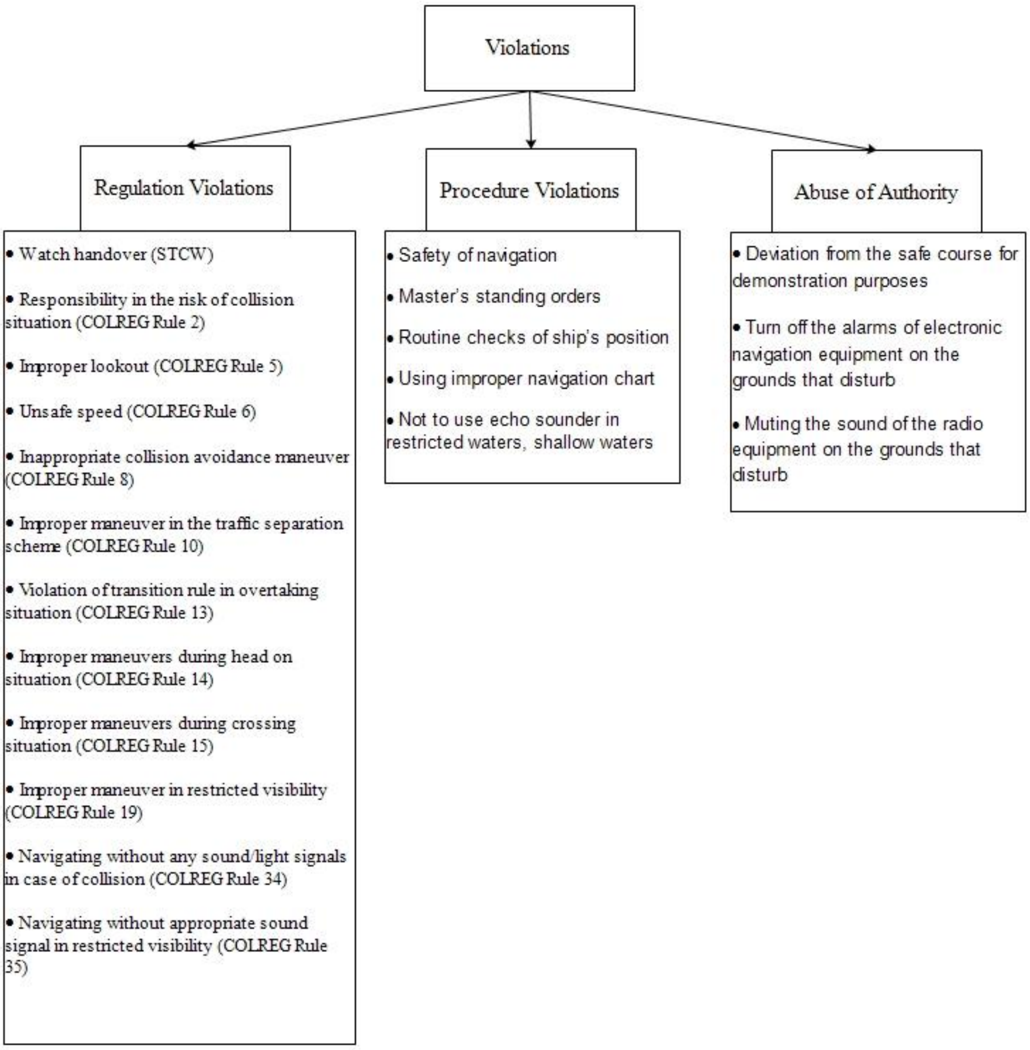

Figure 13. Violations

Table 1. List of maritime accident investigation organizations examined in the study

Name of the Organization	**Abbreviation**	**Central Country(s)**
Accident Investigation Board Norway	AIBN	Norway
American Bureau of Shipping	ABS	USA
Australian Transport Safety Bureau	ATSB	Australia
Bahamas Maritime Authority	BMA	Bahamas
Federal Bureau of Maritime Casualty Investigation	BSU	Germany
Bureau d'enquêtessur les événements de mer	BEAMER	France
Confidential Hazardous Incident Reporting Programme	CHIRP	United Kingdom
Countryman & McDaniel	C& M	USA
Danish Maritime Accident Investigation Board	DMAIB	Denmark
Department of Marine Services and Merchant Shipping	ADOMS	Antique and Barbuda
Dutch Safety Board	DSB	Netherlands
European Maritime Safety Agency	EMSA	Portugal
Global Integrated Shipping Information System	GISIS	United Kingdom
International Transportation Safety Association	ITSA	USA, Canada, Sweden, Netherlands
Isle of Man Ship Registry	IOMSR	United Kingdom
Japan Transport Safety Board	JTSB	Japan
KAIK Accident Investigation Board	KAİK	Turkey
Marine Accident Investigation Branch	MAIB	United Kingdom
Marine Accident Investigation Committee Cyprus	MAIC	Cyprus
Marine Accident Investigators' International Forum	MAIF	United Kingdom
Marine Casualty Investigation Board	MCIB	Ireland
Marine Department-Hong Kong	MARDEP	China
Maritime Safety Administration of People's Republic of China	MSA	China
National Transportation Safety Committee	NTSC	Indonesia
Marine Accident Investigation Department	DIAM	Panama
Philippine Coast Guard	PCG	Philippines
Safety Investigation Authority	SIA	Finland
Swedish Accident Investigation Board	SHK	Sweden
Swedish Transport Agency	STA	Sweden
The Nautical Institute	MARS	United Kingdom
Transport Accident and Incident Investigation Bureau	TAIIB	Latvia
Transport Accident Investigation Commission	TAIC	New Zealand
Transportation Safety Board of Canada	TSB	Canada
United States Coast Guard (Homeport)	USCG	USA
United States National Transportation Safety Board	NTSB	USA

Table 2. The frequency ~~and degree of importance (%)~~ of the factors causing collision accidents

HFACS-PV Model for Collision Accidents				*f*	%
1. ENVIRONMENTAL FACTORS				**103**	**19,92**
a- Internal Environment	Non-conformities and failures preventing ship's motion			14	2,71
b- External Environment	i- Weather Conditions	Impairing Visibility		14	2,71
		Preventing Vessel's Motion		16	3,09
	ii- Local Restrictions			59	11,41
	External Environment Total			89	17,21
2. ORGANIZATIONAL INFLUENCES				**58**	**11,21**
a- Resource Management	i- Human Resources	Training&Familiarization	Navigation Area	4	0,77
			Vessel	12	2,32
		Crew Assignment		4	0,77
	ii-Equipment & Facility Resources	Insufficient Equipment		4	0,77
		Inappropriate Equipments		-	-
		Ergonomic Design Flaws		9	1,74
Resource Management Total				33	6,37
b- Organizational Climate	i-Organizational Structure	Communication&Coordination		-	-
		Chain of Command		-	-
		Distribution of Authority		-	-
	ii- Policies	Promotion		-	-
		Drug& Alcohol		-	-
	iii- Organizational Culture			-	-
Organizational ClimateTotal					
c- Organizational Process	i- Operation Management			2	0,39
	ii- Legal Shortcomings	Procedure Based		6	1,16
		Legislation Based		2	0,39
	iii- Oversight	Risk Management		4	0,77
		Safety Assessment		11	2,13
Organizational Process Total				25	4,84
3. UNSAFE SUPERVISION				**18**	**3,48**
a- Insufficient Supervision				6	1,16
b- Planned Inappropriate Operations				12	2,32
c- Failure to Correct a Known Problem				-	-
4. PRECONDITIONS FOR UNSAFE ACTS				**157**	**30,37**
a- Malfunctions in the electronic navigation aids				**2**	**0,39**
b- Substandart Team Members	a- Substandard Condition of Team Members	i- Adverse Mental Conditions		39	7,54
		ii- Adverse Physical Conditions		3	0,58
		iii-Physical and Mental Limitations		41	7,93
		Substandard Condition of Team Members Total		83	16,05
	b- Substandard Practices of Team Members	i- Readiness for Operation		11	2,13
		ii- Bridge Team Manag.	Inappropriate Management Activities	15	2,90
			Lack of Communication	22	4,26
			Lack of Coordination	24	4,64
Substandard Practices of Team Members Total				72	13,93
5. UNSAFE ACTS				**181**	**35,01**
a- Errors	i- Skill Based Errors			31	6,00
	ii- Decision Based Errors			31	6,00
	iii- Perceptual Errors			29	5,61
Errors Total				91	17,61
b- Violations	i- Regulation Violations			76	14,70
	ii- Procedure Violations			13	2,51
	iii- Abuse of Authority			1	0,19
Violations Total				90	17,40