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Utilisation of cognitive map in modelling human error in marine accident analysis and prevention

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ABSTRACT

Marine accident analysis is one of the most significant milestones in enhancement of maritime safety and environmental awareness. This paper uses human factors analysis and classification system (HFACS) combined with cognitive map (CM) in marine accident analysis. The HFACS–CM model is recognised as hybrid accident analysis approach provides distribution of human error by taking the operational evidence into account. The proposed investigation model is applied to various marine accident cases in order to analyse the role of human factors in the course of events. A man overboard situation during a lifeboat drill, a critical aspect of the evacuation procedure on-board cruise ships, is chosen as a novel case to demonstrate how the HFACS–CM approach operates in practice. Consequently, the study can contribute to identify and reduce human errors in marine accidents.

1. Introduction

Sustainable maritime transportation requires establishing safe, secure, and environmentally friendly organisations in which advanced operational technologies and modern management styles are integrated in the relevant stakeholders (i.e. international shipping companies, shipyards, port and terminals). In recent years, proactive countermeasures which have a close nexus with standardization and quality have become a highly recommended approach for the maritime executives and responsible decision makers. However, there are still large milestones to reach for the future of maritime industry to become an excellent mode of transportation; for instance, there are still many concerns especially about enhancing operational reliability. Indeed, we need to call for more effort in terms of operational safety research in order to achieve the key performance indicators throughout global maritime transportation.

With this insight, maritime safety is one of the most significant issues despite various challenges in shipboard environment. Maritime safety considerations require a set of activities on board ships which have been coordinated and supervised by shore-based organisations. Meanwhile, maritime regulations and legislative activities governed by the International Maritime Organisation (IMO) contribute to enhance the technical standards of maritime operations. The IMO, in this context, deals with maritime safety, maritime environment, maritime security, and other legal matters (Tarelko, 2012). In this respect, International Convention for the Safety of Life at Sea (SOLAS 74), International Convention on Standard of Training Certification, and Watchkeeping for Seafarers (STCW 78), and The Convention on the Prevention of Maritime Pollution (MARPOL 73/78) can be addressed as inclusive conventions in maritime industry (Faturachman and Mustafa, 2012). Besides major conventions, operational safety requirements on board ships have also been supported in the form of international maritime codes. Just to name a few key codes along with the safety considerations, international safety management code (ISM code), international code for fire safety systems (FSS code), international code for the application of fire test procedure (FTP code), international life-saving appliance code (LSA code), and casualty investigation code can be addressed (Tzannatos and Kokotos, 2009; IMO, 2003, 2007, 2008). Despite the number of maritime conventions and codes, the studies on transition of safety requirements towards ship operating environment are highly required (Wieslaw, 2012). Relevance to the mentioned compliance matter, Knapp and Frances (2009) argued the methodological concept to measure effectiveness of maritime conventions. It requires achieving maritime operational excellence to enhance safety standards and technical performance via a continuous monitoring system which provides evidence for detailed safety analysis, critical problem solutions, and emergency planning. Here is a point that a proactive system should be designed to prevent the reoccurrence

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of deficiencies, nonconformities, near misses, hazardous occurrences and accidents.

Marine accidents are one of the major issues for the shipping industry. They mainly result in serious threats to human life, properties and marine environment. In order to minimise marine accidents, international maritime authorities have adopted several conventions in parallel with considerable efforts to maintain a high level of safety standards at sea (O'Neil, 2003; Hetherington et al., 2006). Furthermore, the authorities have been trying to reduce and prevent marine accidents in recent decades in accordance with regulation requirements. Nevertheless, marine accidents still cannot be reduced to the desired levels. In detail, injury or loss of life, damage to ship, damage or loss of cargo and particularly marine environment pollution are some frequent consequences of maritime accident (Hansen et al., 2002; Wang, 2002). Since maritime society, researchers and practitioners have become aware of dangers, marine accident investigation is a highly cited topic in literature.

First of all, it is a very onerous task to determine the number of maritime accidents that are reported or not reported to flag state authorities (Hassel et al., 2011). In order to provide statistical detail in marine accident investigations, comparative studies of vessel accident databases in terms of risk management perspective (Asbjørnslett et al., 2010), and statistical report analysis (Roberts and Marlow, 2002; Darbra and Casal, 2004) have been carried out. It can be noted that studies focused on total loss incidents (Li et al., 2009), touching and grounding (Özgecan et al., 2009), collision, fire and explosion of the ships (Van Drop et al., 2001; Le Blanc et al., 2001). To analyze marine accidents, Mullai and Paulsson (2011) designed a conceptual model to demonstrate empirical data from an operational level. Moreover, marine accident investigation models are supported with well known approaches such as systems theory concept (Leveson, 2004), risk-based modelling (Celik et al., 2010), and probabilistic method (Trucco et al., 2008).

Human error is a dominant factor that contributes to marine accidents (Harrald et al., 1998; Toffoli et al., 2005). The conducted research mainly addressed the role of human errors in maritime accidents. Other major factors are technical failures and management failures as well as operational errors. Considering operational feedback, action to prevent accidents at sea should focus primarily on eliminating human errors. A model study that is based upon human reliability evaluation in Greek ships accidents were proposed by Tzannatos and Kokotos (2009). Moreover, the functions of human factor within maritime safety management systems were studied by Er and Celik (2005). In another study conducted on the challenges of measuring performance variability in complex systems by using human and organisation error modelling (Grabowski et al., 2009). The study was supported with a case application on marine transportation era. Likewise, design-based failure on human error in shipboard operation was proposed by Celik and Er (2007). The paper was supported with the illustrative cases related to the influences of design-based failures on human errors.

Furthermore, Lin et al. (2007) described a system improving article which utilised human-centred system approach to ship facility design. In order to identify the role of human errors in shipping accidents, a hybrid system was proposed to generate an analytical human factor analysis and classification system quantified with fuzzy analytical hierarchy method (Celik and Cebi, 2009). This new approach provided improvement for analytical foundation and group decision-making ability in shipping accident investigation procedures.

Despite the research and technologic innovations in marine industry, the accidents are still an ongoing problem. In addition, human factors still dominates the majority of marine accidents. Thus, this paper aims to remedy this gap to enhance ship safety standards. Furthermore, a marine accident analysis and prevention model in terms of technical understanding of risk and safety linked to human factor is being developed. The main aim is to maximise ship safety standards by eliminating the causal factors in marine accidents. With this insight, the causation is the key term of the suggested marine accident analysis model.

The course of this study is set to build a logical presentation of the research made on the issue. This section explains the motivation behind the research and delivers a literature review on marine accident analysis. In Section 2, a marine accident analysis and prevention model is provided. In Section 3, the model is applied to a real case study. The final section gives the original contributions of the research and prospective issues in accident analysis and prevention.

2. Methodology

The proposed model is based on human factor analysis and classification system (HFACS) integrated with the cognitive mapping (CM) technique. The further sections introduce the HFACS–CM and corresponding application of both methods in literature.

2.1. Human factors analysis and classification system (HFACS)

The HFACS is an analysis technique based on Swiss cheese model (Reason, 1990). A basic structure of the Swiss cheese model for human error causation is illustrated in Fig. 1.

The system is generally used for aviation industry to search and analyse the role of the human factor in accidents (Wiegmann and Shappell, 2003). The aim is to present a comprehensive and simple framework to assist practitioners in investigating and analysing human error. Moreover, it provides the knowledge and tools required to perform a human error investigation for accident. It is illustrating the numbers of causal categories within four levels of failure. The HAFCS mechanism investigates and analyses the active and latent factors causes of accidents. This combination has increased the capability of the mechanism in accident survey practice. The HFACS basically consists of four schematic levels; (i) unsafe acts, (ii) pre-conditions for unsafe acts, (iii) unsafe supervision and (iv) organisation influences. Organisation level includes resource management, organisation climate and the operational

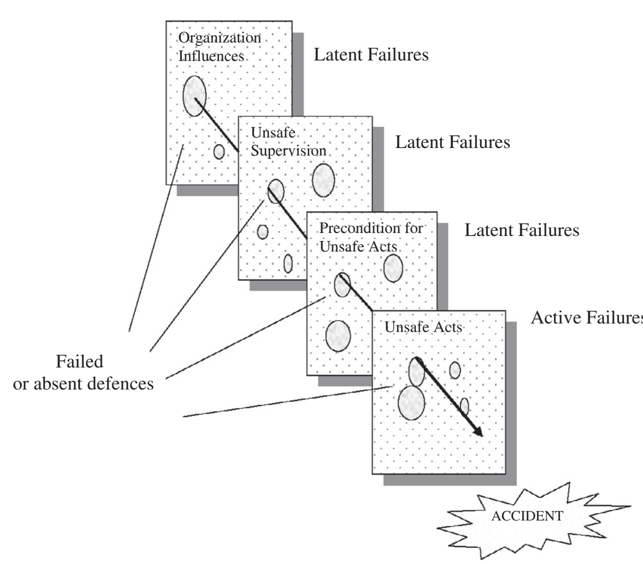

Fig. 1. Swiss cheese model for human error causation.