Safety Science 68 (2014) 169–179

Contents lists available at ScienceDirect

Safety Science

journal homepage: www.elsevier.com/locate/ssci

A hybrid decision-making approach to measure effectiveness of safety management system implementations on-board ships

Emre Akyuz [a,*], Metin Celik [b]

[a] Department of Maritime Transportation and Management Engineering, Piri Reis University, Tuzla 34940, Istanbul, Turkey
[b] Department of Marine Engineering, Istanbul Technical University, Tuzla 34940, Istanbul, Turkey

ARTICLE INFO

Article history:
Received 15 August 2013
Received in revised form 17 February 2014
Accepted 4 April 2014

Keywords:
ISM Code
Safety management system
Maritime regulations
Decision-making

ABSTRACT

Future of ship safety is recently a core topic discussed in various platforms by maritime stakeholders. Regarding this issue, it is so significant task to achieve maritime regulatory compliances with ship operational requirements to ensure safe operations on-board ships. For instance, it is one of the most recently amendments to evaluate safety management system (SMS) effectiveness. The maritime research in this context focuses on promoting a hybrid decision-making approach to measure effectiveness of safety management system implementations on-board ships. The approach incorporates Analytical Hierarchy Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS). It determines the key performance indicators (KPIs) with tangible/intangible data in decision analysis which enhance shipboard safety conditions. The main findings highlight that number of detentions, crew injuries on-board ship, and major non-conformities are considered as assessment factors of ship SMS. The proposed approach enables to review the SMS practices systematically that is required by recent amendments of ISM Code. Thus, the proposed approach remedies the gap between safety science and maritime transportation industry in terms of adopting operational data in safety analysis. Consequently, the research outcomes encourage the maritime researchers, safety engineers and ship operators.

1. Introduction

Safety is the one of the key aspects of sustainable maritime transportation. It directly deals with the management and operation of ships. The achievements of the International Maritime Organization (IMO) related to maritime safety and marine environmental protection are marvellous. Principally, the IMO governs the safety, security and environmental dimensions via regional Port State Control (PSC) authorities in accordance with the designated memorandum of understandings (MOUs). In current situation, the IMO declared that there are now enough regulations in place and the problem is one of implementation and enforcement. Indeed, maritime authorities encourage the ships operators to fulfil the requirements of adopted rules and regulation. Therefore, safety standards on-board ships contribute to threat unsafe conditions along with the operation process. Hereby, it very critical aspect to ensure conformity among regulatory execution and operational requirements. In order to implement and enforce regulations in a good order, ship management organisation should establish an advance monitoring system. To continuous control and verification might improve the maritime safety and environmental protection standards on a global basis (IMO, 2013).

Besides major conventions, operational safety requirements on-board ships have been supported in the form of international maritime codes. International safety management code (ISM Code) in that context can be given an example in terms of safety considerations. The code requires establishing a safety management system (SMS) which functioning to improve safety and environmental prevention requirement.

Since maritime safety is essential key factor in terms of maritime transportation, several studies have been conducted over the last decades. Tarelko (2012) explained origins of ship safety requirements based on the IMO policy supported with reactive or proactive actions. Furthermore, the outcomes of studies concerning marine accident statistics have potential to make constructive decisions on maritime safety (Cariou et al., 2008; Mullai and Paulsson, 2011). In addition, a methodology based on fuzzy logic technique was developed by Gaonkar et al. (2011) to evaluate safety parameter in maritime transportation. Likewise, several advance models comprising Markov chains (Kolowrocki and Soszynska, 2011) and Monte Carlo simulation (Montewka et al., 2010) have been recently utilised in the same field.

* Corresponding author. Tel.: +90 216 581 00 50; fax: +90 216 581 00 51.
E-mail addresses: emreakyuz82@gmail.com, eakyuz@pirireis.edu.tr (E. Akyuz).

http://dx.doi.org/10.1016/j.ssci.2014.04.003
0925-7535/

On the other hand, Heij et al. (2011) proposed a quantitative risk assessment approach demonstrated with deficiency databases obtained from ship inspection. In other respect, a system of hierarchical scorecards (SHS) has been developed to evaluate the implementation performance of maritime rules and regulations (Karahalios et al., 2011). In addition, Yang et al. (2013) reviews the challenges of maritime safety analysis and the different approaches used to quantify the risks in maritime transportation. The article has provided an update review of maritime safety analysis over the last decades.

The revived studies show that maritime safety is playing a critical role on shipboard managements and operations. In order to maximise maritime safety on-board ship, this study proposes a hybrid decision-making approach (AHP–TOPSIS) to assess effectiveness of SMS implementation on-board ship. The purposes of the study are highlighted as follows;

1. Enhancing safety management implementations on-board ships.
2. Developing a methodological approach to measure safety performance.
3. Executing ship operational procedures compliance with maritime regulations.

In this context, this section expresses the motivation behind the research and literature review on maritime safety. The next one deals with the literature review on ISM code and SMS. Then, research background upon SMS and ISM Code (2010) amendments is also provided. Furthermore, the methodology is proposed and demonstrated with a case study. The final section gives the original contributions of the research, discussion and prospective issues for enhancement maritime safety.

2. Literature review

The ISM Code, which is enforced in 1998, refers that international safety management code for safe operation ships and pollution prevention. The Code was initially structured to prevent maritime accidents mainly caused from sub-standard management and operation. Regarding this issue, the purpose of Code is to maintain international standards for safe management and operation on-board merchant ships (IMO, 2002). The ISM Code was first introduced in early 1980s during an investigation for tanker ships whose management standards had found inadequate (IMCO, 1982). This investigation report prompted tanker ship owners to consider and restructure safety policy. Moreover, it raised the awareness on-board ships and shore-based organisation.

The introduction of the Code affected company management system significantly, beyond various shipping companies redesigned their organisation. It required a good management practice towards safety and pollution prevention. Therefore, an implementation plan has to carry out the requirements of ISM Code constructed by shipping company (Hunter, 1998). In detail, the shipping companies are required to develop their own policies, responsibilities and procedures under SMS. The system includes various procedures such as risk assessment, preventive action planning, maintenance planning, accident reporting, emergency response plan and internal audits.

In the literature, we found a few studies mainly concern the design and implementations of SMS. In the first segment, Hess et al. (2011) discussed on establishing a risk assessment and classification system on-board ship in accordance with ISM Code. The paper supported with methodology for preparation of a risk control plan connected with work activities on-board ship. Another study uses a hybrid method to redesign of ISM Code procedure to cover precautions against occupational accidents on-board chemical tankers (Celik, 2010). The proposed method has positive impact to extend ISM Code procedure to OHSAS 18001:2007 standards in chemical tankers operation. According to the research (Celik, 2010), the ISM Code enables a broad procedural support to crewmembers against safety and environmental related threads. In that condition, the responsible executives ensure transformation of ISM Code procedures into operational decision support especially for cargo handling, tank inspection, gas freeing, tank cleaning, and tank purging operations. It is another viewpoint (Celik, 2009) to design an integrated quality and safety management system (IQSMS) for shipping operations to deal with shortfalls in the shipping management. The mentioned study (Celik, 2009) utilised axiomatic design principles to assess the conformity level of ISO integration to execution process of ISM code in merchant shipping. In order to provide a strategy for the safe carriage of liquid chemical cargoes in chemical tankers, a qualitative research has been performed by using SWOT analysis (Arslan and Er, 2008). Another research attempting to examine the precaution priorities during cargo operation in chemical tankers have been studied by Arslan (2009). In this study, AHP method is utilised to prioritize the precautions in order to explain risk assessment options in chemical tanker fleet. Furthermore, another study based on a MILP formulating has been introduced last decade (Jetlund and Karimi, 2004). In this paper, authors address the scheduling of multi-parcel chemical tankers which are carrying of numerous chemical cargoes. Moreover, a model based approach upon systematic analysis has recently been introduced (Celik et al., 2013). The aim of this research is to determine the principle particulars of the optimum vessel based on the minimum construction cost of chemical tankers.

A different perspective is raised by Goulielmos and Giziakis (2002) by using the fundamental of the complexity theory to reduce bureaucracy level of the SMS in practice. Likewise, another study has recently been offered to evaluate the effectiveness of the ISM Code (Bhattacharya, 2012). The article reveals that there is a wide gap among the perception of seafarers and company managers in the ISM Code implementation. This is very challenging problem subject to factual implementation of SMS on-board ships. In addition, Anderson (2002) conducts a wide range of survey to analyse awareness of seafarers and shore-based manager upon the efficiency of ISM Code implementation on-board ship. On the effectiveness of ISM Code implementation, Tzannatos and Kokotos (2009) also carried out an analysis over the 268 ship accident during before and after implementation of ISM Code period. The study reveals that implementation of the code led to decrease human-induced marine accident. Likewise, another study conducted on shipping accident on Greek-flagged ships in order to evaluate the enforcement of the ISM Code between 1995 and 2006 through applying of the data mining tool (Kokotas and Linardatos, 2011).

The ISM Code establishes safety management objectives and it requires a SMS which should be established by ship management company. Thereafter, the company has to set and accomplish a policy for achieving those objectives. To sum up, it encourages the development of a safety culture on-board ship. The functional requirements of SMS associated with the operation of the ship are expressed as follows (Farthing, 1997; ISM Code, 2010); (i) safety and environmental protection policy, (ii) safety and environmental protection procedures, (iii) communication procedures between the company and on-board ship, (iv) procedures for reporting accident or incidents, (v) emergency response plan and (vi) internal audits. The flag state of each ship has a legal right to attend management company and conduct regular audit to verify that the company accomplish these provisions of code. If the flag state found everything in order, they issue a certificate named documents of compliance (DOC). In addition, flag state may conduct