Strategic management approach for port state control

The Black Sea Memorandum of Understanding detention analysis

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Received 7 October 2019
Revised 22 October 2019
23 October 2019
30 October 2019
Accepted 1 November 2019

Abstract

Purpose – The purpose of this study is to fill the gap and apply a fault tree analysis (FTA) in detention lists of Black Sea Region published port state reports from 2005 to 2016. The study analyzes valid records of 2,653 detained ships with 6,374 deficiencies based on a strategic management approach. This paper sets up FTA technique to assess the detention probability of a random ship which calls the Black Sea Region with the help of detention lists published within subject years.

Design/methodology/approach – This paper is not published elsewhere, and it is based on an original work, which figures out detention probability of a regular ship at Black Sea Region port state control from published lists of Black Sea Memorandum of Understanding (MoU). By utilizing these detention lists, a generic fault tree diagram is drawn. Those probabilities could be used strategically with the most seen deficiencies in the region which all could guide the users, rule makers and the controllers of the maritime system.

Findings – FTA has conducted based on the data which was collected from website of BS MoU detention lists that published from 2005 to 2016. Those lists have been published on monthly basis from 2011 to 2016 and on quarterly basis from 2005 to 2010. Proper detention records have been included into the research, whereas some missing records were excluded. Subject lists have been harmonized and rearranged according to Black Sea MoU Detention Codes which was published on October 2017 at Black Sea MoU's website. According to BS MoU Annual Reports, 58,620 ships were inspected from 2005 to 2016 as seen in Table 1. Those ships were inspected by each member country's PSOs in the light and guidance of predefined selection criteria of the region. Detention frequency of inspected ships detected as 0.103116 which explains any ship that called any port in the Black Sea Region could be 10% detained after inspected by PSO. Also, each intermediate event-calculated frequency enlightens the probabilities of nonconformities of ships. Although those deficiencies show structural safety and security nonconformities, those probabilities also prove us that management side of the ships are not enough to manage and apply a safety culture. By the light of that, ship owners/managers could see the general nonconformities according to regional records and could manage their fleet and each ship as per those necessities.

Research limitations/implications – In the light of the above analysis, the future research on this subject could be studied on other regions which might enable a benchmark opportunity to users. Also, insurance underwriters have their own reports and publications that could clarify different points of view for merchant mariners and regulators. In this research, FTA is used as a main method to figure out the root causes of the detentions. For future researches, different qualitative and quantitative methods could be used under the direction of subjects.

Maritime Business Review
Vol. 5 No. 3, 2020
pp. 279-290
Emerald Publishing Limited
2397-3757
DOI 10.1108/MABR-10-2019-0043

Practical implications – Detention frequency of inspected ships detected as 0.103116 which explains any ship that called any port in the Black Sea Region could be 10% detained after inspected by PSO. Also, each intermediate event-calculated frequency enlightens the probabilities of nonconformities of ships. Although those deficiencies show structural safety and security nonconformities, those probabilities also prove us that management side of the ships are not enough to manage and apply safety culture. By the light of that, ship owners/managers could see the general nonconformities according to regional records and could manage their fleet and each ship as per those necessities.

Social implications – With the nature of carriage, shipping business carry out its essential economic attendance in world trade system via inclusion in national and international transportation. As a catalyst in international trade, shipping itself enables time, place and economic benefits to users (Bosneagu, Coca and Sorescu, 2015). Social and institutional pressures generate shipping industry as one of the most regulated global industries which creates high complexity. Industry evolved to multi-directional structure ranges from international conventions (IMO and ILO) to "supra-national interferences" (EU directives), to regional guidance (MoUs) to national laws (flag states). Ship operators endeavor to adopt/fit its industry environment where rules are obvious. With adaptation of industrial environment, ship operators are able to create an important core competency.

Originality/value – This study enlightens the most recorded deficiencies and analyzed them with the help of fault three method. These calculated frequencies/probabilities show the most seen nonconformities and the root causes of detentions in the Black Sea Region in which those results will be benefited strategically that enables a holistic point of view that guide the owners/managers, charterers/sellers/shippers, classification societies, marine insurance underwriters, ship investors, third parties, rule makers and the controllers of the system to apply safety culture.

Keywords Fault tree analysis, Strategic management, Memorandum of Understanding, Port state control, Ship detention

Paper type Research paper

1. Introduction

World trade substantially depends on maritime transportation. Merchant ships that are main vehicles of cargo carriage are subject to important international regulations. These regulations are inspected by flag and port state authorities (Heij *et al.*, 2011). Ship inspections are enablers of safety and security regulations under responsibility of flag states and port state controls (PSC).

Shipping business is regulated via three processes: construction, maintenance and commercial life/operation of merchant ships. These processes are the parts of the control and verification system of the commercial shipping. International Maritime Organization (IMO) as a leading regulator of this system mediates the rules to member states. The system works together with classification societies, insurance companies, flag states and port states where International Labor Organization (ILO) takes part as another regulator body (Knudsen and Hassler, 2011).

After some serious catastrophic tanker accidents through 1970s, PSC came out as a control mechanism to ensure safety regulations in 1980s. As an accepted belief, flag states are unable to control all vessels under their authorities where port states take the duty to inspect foreign flagged vessels to enable international safety and security standards under the supervision of IMO and ILO (Cariou *et al.*, 2007).

Countries affiliate on Memorandum of Understanding (MoU) on a regional basis and establish PSC regimes. PSC controls are divided into nine regional areas, all of which are established under different MoUs and act as safety inspector of world shipping to find out substandard ships (Yang and Wang, 2015).

The aim of the PSC is to catch high-risk vessels under poor technical, operational or managerial conditions that is threat to safety, environment or human lives. The PSC system under different MoUs identifies their own ship selection procedures and applies

international regulation necessities (Cariou and Wolff, 2015). Disaster risks that any ship could be involved are total or partial loss of ship and cargo, environmental harm, loss of human life and/or injuries and damage to third parties. PSC inspections could reduce different disaster risks (Heij *et al.*, 2011).

As seen from literature, fault tree analysis (FTA) is studied for a long time on many topics such as engineering, management and decision science fields. However, its application in PSC is still not enough and infrequently reported. The aim and the motivation of the study is to fill this gap and apply FTA in detention lists of Black Sea Region published port state reports from 2005 to 2016. The study analyzes valid records of 2,653 detained ship with 6,374 deficiencies based on a strategic management approach. This paper sets up FTA technique to assess detention probability of a random ship which calls the Black Sea Region with the help of detention lists published within subject years. Section 2 gives brief information about history of PSC, applications and the objects; Section 3 shows the methodology of the research, including definitions. Section 4 implies the application of the proposed approach, followed by discussion and conclusion sections.

2. Literature review

Maritime industry is managed via international regulations and applications. The main rule makers in the shipping sector are IMO and ILO which mandate and prescribe important safety, security and environmental conventions (Heij *et al.*, 2011).

IMO, as one of the bodies of United Nations, started to mandate international treaties regarding marine safety and pollution prevention in 1950s in the course of standardized procedures that could be applied all over the world. Those detailed conventions require many important applications that could be implemented by ship, ship's operator (shipowner/ship manager) and flag state. After the Amoco Cadiz oil spill, the Hague Memorandum was signed between eight North states in 1978, where the roots of PSC have begun to sprout. In 1980, 14 European countries met in Paris with IMO and ILO representatives. The main approaches gather around the separation of substandard ship/applications and establishment of accepted worldwide international implementations to ensure safety and security. Paris MoU and PSC have established and become a guide for other regional MoUs (Özçayir, 2008; Fan *et al.*, 2014).

As regional occurrence, MoUs come together and apply port state inspections to selected ships. There are nine major regional areas covered by PSC which are West and Central Africa (Abuja MoU), the Riyadh MoU, the Black Sea Region (Black Sea MoU), the Indian Ocean (Indian Ocean MoU), Caribbean (Caribbean MoU), Asia and the Pacific (Tokyo MoU), the Mediterranean (Mediterranean MoU), Latin America (Acuerdo de Viña del Mar) and Europe and the North Atlantic (Paris MoU) (Bang and Jang, 2012; Knapp and Franses, 2007; Akyuz *et al.*, 2016).

PSC is a mechanism of control that foreign flagged ships are inspected by Port State Control Officers (PSCO). As an international application pervasive to all regions, shipowners and managers have to set their systems for the sake of businesses they manage. As an effective system, PSCs work as a safety net of shipping (Özçayir, 2008; Graziano *et al.*, 2018).

One of the nine regional MoUs, as explained before, is Black Sea MoU (BS MoU) which was established in 2000 with participation of six Black Sea Region countries including Romania, the Russian Federation, GA, Ukraine, Bulgaria and Turkey to eliminate substandard ships. As a region, Black Sea attracts notices because of some substandard ships disallowed from Europe rotate to Black Sea Region which afterwards caused the establishment of Black Sea MoU (Bang and Jang, 2012). Under the guidance of Paris MoU,

all regional controls try to operate similar procedures and applications under the relevant IMO conventions (Knapp and Franses, 2007).

As indicated, ships are subject to PSC inspections and depend on specific selection criteria according to Black Sea MoUs predefined standards. Those standards are published under the name of BS MOU New Inspection Regime (BS-IR, 2016) and comprise standards in selection of ships for inspections. Within these inspection standards ships are categorized as High Risk Ships (HRS), Standard and Low Ship Risk (LRS) in which these are the risk levels under the inspection regime. Black Sea Information System (BSIS) has assigned to targeted ships according to generic and historic parameters. Some points are given according to ships past performance and current status afterwards weighting points and indices designate a categorization (BS MoU, 2018).

According to abovementioned explanations, this study aims to strategically identify detained ship causes under the light of BS MoU detention lists published from 2005 to 2016. A graph on the root causes of BS MoU detentions has been drawn.

3. Methodology: fault tree analysis

This research applies FTA as a strategic approach to figure out main detention causes, their relationships and probabilities. Detention codes are gathered from BS MoUs detention lists. All codes are assigned by PSOs during ship inspections, according to predetermined deficiency code list which was prepared in the light of IMO conventions.

The potential detention probabilities help users, rule makers and controllers to understand the root causes of problems, which also strategically guide ship operators to figure out main challenges of operation/management of ships. It could be seen from the literature that FTA has been studied on many topics from nuclear sector to health sector for a long time. However, its application on port state inspection is still not enough. The following section informs theoretical background of FTA in the literature.

As a logical and graphical model, a fault tree consists of faults/basic events (BE) which are interrelated with each other that are created the infrastructure of top event (TE) (Rajakarunakaran *et al.*, 2015; Uğurlu *et al.*, 2015, 2016; Lavasani *et al.*, 2015). FTA implements Boolean logic which is used to get minimal cut sets (MCS) and implies Boolean algebra to figure out system TE failure probability (Sahin, 2017; Kabir *et al.*, 2016; Komal, 2015), which uses AND or OR gates to indicate the unions of failures that are necessary and sufficient to cause the system failure (Kabir *et al.*, 2016). The symbols of FTA can be seen in Figure 1.

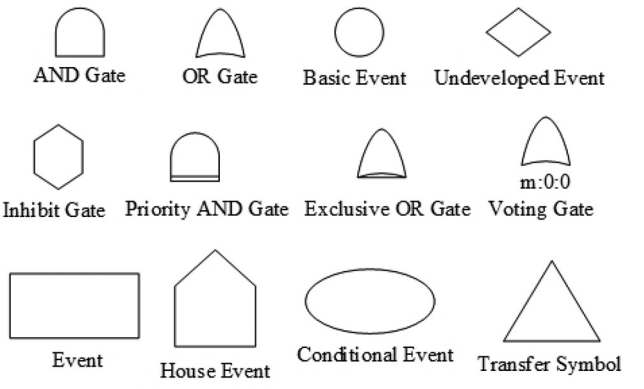

Figure 1.
Symbols of FTA

The classic FTA is epitomized by real values of failure probabilities (crisp numbers) and logical AND or OR gates which symbolize the interest between input and output to reunite BEs according to their relation. Boolean algebras are disposed to mathematically perform the tree diagram and figure out the outputs of connected logic gates (Komal, 2015; Lavasani *et al.*, 2015).

According to literature, FTA is used to interpret system safety and reliability as a technique which is used as a logic diagram that is quantifying the probability of unusual events (Lin and Wang, 1997). Both of qualitative and quantitative analysis could be viable where qualitative analysis inheres deductive. Quantification of fault trees is calculated for the probability of every MCS (Kabir *et al.*, 2016).

As a modeling tool, FTA works with "*backward logic*" in which TE could be separated into BEs (Bedford and Cooke, 2009). The probability of an incident is between 1 and 0 which, on the other hand, could be express as the frequency of the occurrence (Frame, 2003) also the likelihood of the event (Nikolaidis and Haftka, 1998). According to Lavasani *et al.* (2011), below-mentioned equations could be used in the context of the gates as follows:

The probability of an AND gate event could be gathered by equation (1) as

$$P = \prod_{i=1}^{n} Pi \tag{1}$$

The probability of an OR gate event could be gathered by equation (2) as

$$P = 1 - \prod_{i=1}^{n} (1 - Pi) \tag{2}$$

4. Application

This section describes the problem and applies FTA to detained ships that called ports which are under the authority of BS MoU. The detained ships have been recorded by each PSO and published by the BS MoU. The detention fault tree is drawn with the help of mentioned records, and the results are evaluated by using strategic management approach.

4.1 Problem description

Port states, as a responsible body, apply a targeting system to inspect foreign flag ships which call their ports. They, as a port state authority, have right to inspect, rectify and detain ships (Bang and Jang, 2012). If subject ship has minor/major defects, the detention could last until the ship and/or ship managers could take corrective actions and recoveries. This research checks BS MoU detention lists and finds out that 2,653 ships were detained with 6,374 deficiencies recorded from 2005 to 2016.

This study uses FTA as a strategic management tool to assess probabilities and analyze the maritime environment. Also, this research turns analyzed records into practical outcome and draws the fault tree of the detained ships with root causes. According to strategic management approach, stakeholders of the maritime trade system could use subject analysis and evaluations for the sake of their businesses while taking corrective actions.

This paper applies probability theory and provides fault tree diagram belong detained ships and root causes. The following part of the research clarifies how such root causes as BE evaluated and propose a failure probability of a ship that called any port at the Black Sea

Region. Moreover, this paper provides theoretical and practical approach to analyze and evaluate the port state records in the context of Black Sea Region.

4.2 Findings

FTA has conducted based on the data which was collected from website of BS MoU detention lists that published from 2005 to 2016. Those lists have been published on monthly basis from 2011 to 2016 and on quarterly basis from 2005 to 2010. Proper detention records have been included into the research where some missing records were excluded. Subject lists have been harmonized and rearranged, according to Black Sea MoU Detention Codes which was published on October 2017 at Black Sea MoU's website.

According to BS MoU Annual Reports, 68,946 ships were inspected from 2005 to 2018, as seen in Table 1. Those ships were inspected by each member country's PSOs in the light and guidance of predefined selection criteria of the region.

Each member state kept records for each inspection and codified deficiencies with the same numerical system where each code identifies a nonconformity/problem. Table 2 could be check as an example. These codes given according to deficient parts and systems of inspected ships which were rectified before departure. The Port State has the authority not to leave any ship until the required adjustments are done for the sake of sailing.

In Table 2, the explanation of Code 7 is shown as an example. BS MoU Detention Codes List has numerical system, which begins from Code 01 to Code 99. Those codes designated according to various sources and requirements belongs IMO and ILO international conventions. Even ship's flag state is a contractor or not to the mentioned international conventions, port state has right to inspect all ships that call the ports under their authority. Any inadequacy in those codes results as a detention which constrains ship from commercial operations. According to BS MoU, detention lists fault tree of detained ship is drawn as given in Figure 2. The meaning of codes mentioned in Figure 2 could be seen from BS MoU deficiency codes (www.bsmou.org).

In the direction of Figure 2, the probability of detention that any ship called any member state port in the Black Sea Region has calculated by implementing equation (2) because BEs in above tree are interconnected with OR gates. Results calculated on the basis of 58,620

Years	No. of inspected ships
2005	5,069
2006	4,658
2007	4,499
2008	5,161
2009	4,805
2010	4,929
2011	4,657
2012	4,607
2013	5,080
2014	5,092
2015	4,997
2016	5,066
2017	5,112
2018	5,214
Total	68,946

Source: BS MoU Annual Reports 2014, 2018

Table 1.
Number of inspected ships

Code	Meanings/nonconformity
07-	Fire safety
07101	Fire prevention structural integrity
07102	Inert gas system
07103	Division – decks, bulkheads and penetrations
07104	Main vertical zone
07105	Fire doors/openings in fire-resisting divisions
07106	Fire detection and alarm system
07107	Fire patrol
07108	Ready availability of firefighting equipment
07109	Fixed fire extinguishing installation
07110	Firefighting equipment and appliances
07111	Personal equipment for fire safety
07112	Emergency escape breathing device and disposition
07113	Fire pumps and its pipes
07114	Remote means of control (opening, pumps, ventilation) machinery spaces
07115	Fire-dampers
07116	Ventilation
07117	Jacketed high-pressure lines and oil leakage alarm
07118	International shore connection
07120	Means of escape
07121	Crew alarm
07122	Fire control plan
07123	Operation of fire protection systems
07124	Maintenance of fire protection systems
07125	Evaluation of crew performance (fire drills)
07126	Oil accumulation in engine room
07199	Other (fire safety)

Source: BS MoU Detention Code List, 2017

Table 2. Nonconformity code 07- definitions from BS MoU detention code list

inspected ships which of 2,653 were recorded as detained from 2005 to 2016. Each numerical code's frequency was taken into account to reach the TE. The frequencies of intermediate events (Codes) and TE (Ship Detention in the Black Sea) are given in Table 3.

5. Discussion

As per the above explanations, the total inspected ships by PSOs between 2005 and 2016 in the Black Sea Region were 58,620, in which 2,653 were detained. Detention analysis is calculated with proper records from that point of view and fault tree diagram is drawn with the help of numerical codes.

As seen from Table 3, detention frequency of inspected ships detected as 0.103116 which explains any ship that called any port in Black Sea Region could be 10 per cent detained after inspected by PSO. Also, each intermediate event-calculated frequency enlightens the probabilities of nonconformities of ships. Although those deficiencies show structural safety and security nonconformities, those probabilities also prove us that management side of the ships are not enough to manage and apply a safety culture. By the light of that, ship owners/managers could see the general nonconformities according to regional records and could manage their fleet and each ship as per those necessities.

The ratios of detained ships that call Black Sea Region are shown in Table 4. Those ratios show the management faults that belongs ship types under BS Inspection Regime.

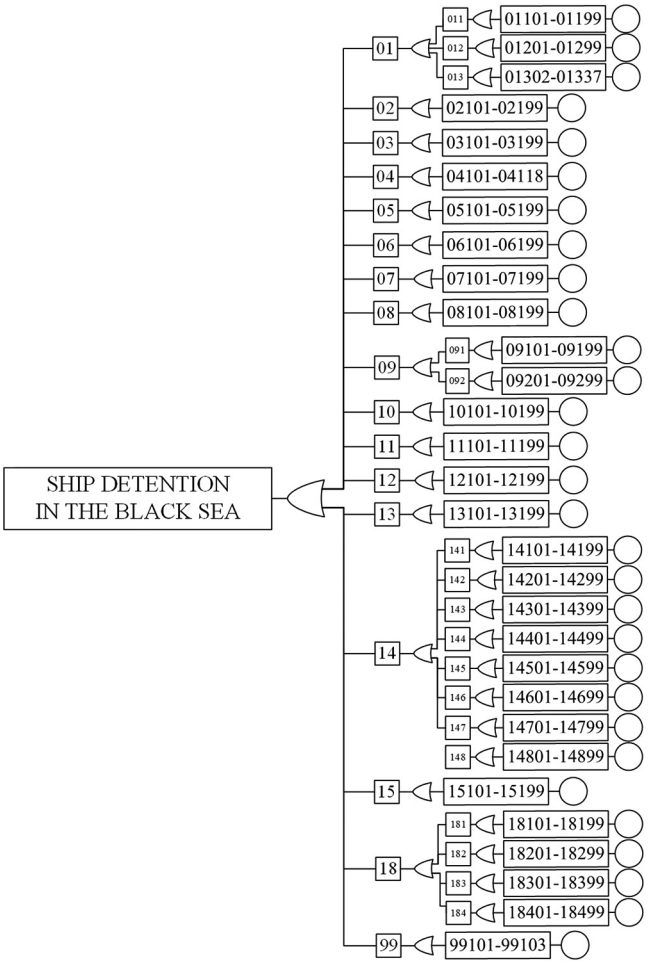

Figure 2.
A fault tree of ship detention in the Black Sea Region

With the help of Figure 2, the most common deficiencies could be analyzed and managers of the shipowning companies and third parties could take necessary steps to figure out the problems of managing ships under their fleet.

Based on the analysis, the frequencies of BEs/deficiencies recorded by PSOs are given in Table 5. According to calculations, the most seen nonconformity is the deficiency of lifeboats, which is followed by emergency fire pump and pipes. From the strategic point of view, ship operators can check and understand the main defects, and take necessary precautions for the sake of commercial operations. Those deficiencies are the main problems of many ships which endanger the safety, security and environment performance of international shipping.

With the nature of carriage, shipping business carry out its essential economic attendance in world trade system via inclusion in national and international transportation. As a catalyst in international trade, shipping itself enables time, place and economic benefits

Codes	Meanings	Calculated frequency
Intermediate events		
01	Certificate and documentation	0.011943
02	Structural conditions	0.007023
03	Water/weather tight conditions	0.005922
04	Emergency systems	0.013159
05	Radio communications	0.005632
06	Cargo operations, including equipment	0.000380
07	Fire safety	0.016827
08	Alarms	0.001569
09	Working and living conditions	0.005278
10	Safety of navigation	0.010950
11	Life saving appliances	0.015462
12	Dangerous goods	0.000034
13	Propulsion and auxiliary machinery	0.003714
14	Pollution prevention	0.002522
15	ISM	0.006059
18	Labor conditions	0.001466
99	Other	0.000307
Top event (TE)	*Ship detention*	*0.103116*

Table 3.
Frequencies of fault tree

Ship types	Ratios (%)
Bulk carrier	16
Ro-Ro/passenger	5
Tanker(oil/chemical)	12
Refrigerated cargo carrier	4
General cargo/multipurpose	58
Container	2
Others	3

Table 4.
Detained ship types between 2005 and 2018 by BS MoU

Codes	Meanings	Calculated frequency
11101	Lifeboats	0.006414
04102	Emergency fire pump and its pipes	0.005356
04103	Emergency, lighting, batteries and switches	0.004622
07117	Jacketed high-pressure lines and oil leakage alarm	0.002917
10111	Charts	0.002525
09232	Cleanliness of engine room	0.002439
07116	Ventilation	0.002286
15199	Other (ISM)	0.002252
07106	Fire detection and alarm system	0.002064
01214	Endorsement by flag state	0.002013

Table 5.
Most recorded basic events/deficiencies 2005-2016

to users (Boşneagu *et al.*, 2015). Social and institutional pressures generate shipping industry as one of the most regulated global industries which creates high complexity. Industry evolved to multi-directional structure ranges from international conventions (IMO and ILO) to "*supra-national interferences*" (EU directives), to regional guidance (MoUs) to

national laws (flag states). Ship operators endeavor to adopt/fit its industry environment where rules are obvious (Mitroussi, 2013).

With adaptation of industrial environment, ship operators are able to create an important core competency. As seen from Table 4, most of the operators failed to apply basic safety and security requirements which originates doers a commercial success. That success creates unique characteristic. As an important feature, strategic thinking offers a trade-offs in competing; it is important as choosing "*what not to do*" while drawing the way of choices (Porter, 1996). Table 5 shows the operational differences of ship operators as a main failure root that is faced through managerial applications. Those differences show a missing part in operators' strategies.

One of the main questions in strategic approach is how could organizations "*achieve and sustain*" competitive advantage (Teece *et al.*, 1997). Applying strategic thinking to the operations of the organizations requires the environmental knowledge and information about rivals. Analyses of BS MoU detention ship is a good source of information that gives brief knowledge about the main problems of the sector. And with the help of fault tree of BS region, ship operators realize main deficiencies of competitors and use that knowledge to create their unique, firm-specific sources.

How those defects and problems could be overcome is the main problem of merchant shipping. The safety system from the very beginning established on those issues with the directions of IMO, ILO, classification societies and marine insurance underwriters. The chain of the system requires strategic collaboration with the ship operators where all these necessities are seen mostly as paper work by operators and ship crew.

The most important inference could be seen as safety system is working and has dissuasive power on ships and ship owners/managers. Any nonconformity could risk commercial reputation of the operator, which works as deterrent for the system.

6. Conclusion and future research directions

As an important stakeholder of international trade, shipping business is ruled by many international rules guided on security, environmental issues and safety practices. Those rules all serve in the light of the same purpose from the very beginning under governance of IMO, ILO and flag states. As a worldwide application, PSCs serve as a "*safety net*" of the system with the regional applications. In this research, BS MoU is chosen to analyze the root causes of regional detentions. Interrelationships of deficiencies and frequency calculations are conducted by using FTA method. With help of probability theory, the likelihood/frequency of detention probability of a random ship that called Black Sea Region is assessed from the published records of the BS MoU.

This study enlightens the most recorded deficiencies and analyzed them with the help of fault three method. These calculated frequencies/probabilities show the most seen nonconformities and the root causes of detentions in the Black Sea Region in which those results will be benefited strategically that enables a holistic point of view that guides the owners/managers, charterers/sellers/shippers, classification societies, marine insurance underwriters, ship investors, third parties, rule makers and the controllers of the system to apply safety culture.

The research has some limitations and further research into this area should be extended. This study is designed on an FTA method to provide a solid base to the field and to figure out the root causes of the detentions. The limitations and suggestions for further studies should be the following in the path of this study, some qualitative and quantities researches could be conducted as a case study or focus group, survey or as an interview to check the practical view to collect data and explore reasons to understand the problems of ships and

its effects to the maritime organizations. Also, some benchmarking studies regarding organizational performance or effectiveness could be conducted. In the light of above analysis, the future research on this subject could be based on other regions which might enable a benchmark opportunity to users. Also, insurance underwriters have their own reports and publications that could clarify different points of view for merchant mariners and regulators.

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