JOURNAL OF MARITIME RESEARCH

Vol XIII. No. I (2018) pp 58–66

ISSN: 1697-4040, www.jmr.unican.es

Safety indications of navigation audit (bridge checklists) for tankers to develop a vessel inspection score

Murat H. Altun[1]

ARTICLE INFO

Article history:
Received 18 February 2018;
in revised form 8 March 2018;
accepted 12 April 2018.

Keywords:
Tanker, Bridge, Safety, Inspection score, Operation risks.

ABSTRACT

Significant amount of world trade has been made by maritime transportation. World maritime trade fleet reached 1.5 billion deadweight tons, world maritime trade volume was 9 billion tons and world maritime trade in terms of financial value reached 9 trillion dollars (Maritime Trade Statistics, 2015). In recent years there has been an increase in the quantity and tonnage of tanker type vessels, the requirement for well experienced and qualified personnel has arisen and it has become increasingly difficult to find experienced and qualified seaman to work on these types of vessels. At the same time, major oil companies (MOC), port states, classification societies and flag states intensified their inspections on tankers so that these types of vessels can operate safely. In spite of all this, the pressure of the desired inspections as well as the busy cargo operations for tankers are felt to be too much. In this study, details will be identified such as finding the root causes, identifying the risks, understanding the possible consequences and determining the working areas during the ship personnel's, operators', auditors' and charterers' working and selection periods. By this way, it will be offered a clearer choice to ship charterers (MOCs) that which ship is better for the company own interests.

1. Introduction

Tanker vessels (crude oil, chemical, product and liquefied gas tankers) has a significant share in the world maritime trade. Figure 1 gives the distribution of world maritime trade by ship type (Review of Marine Transport, 2016).

In order to enhance the profitability of marine trade, environment awareness and human safety, it is needed to perform the vessel bridge inspections in an effective and efficient way. The objective of bridge inspection is to identify the administrative and operational faults, deficiencies and nonconformities on board and to find the most effective and efficient solutions against them. During these inspections, it is examined whether a ship has the necessary procedures, rules and policies during navigation, port stay period, anchorage, berthing and unberthing maneuvers and whether they are applied or not.

When considered the need to improve the quality of tanker management self-assessment (TMSA) for tanker operator companies, this study will be decisive in terms of how and how to improve themselves. The deficiencies weighted at different levels by the ship assessing authorities, will reveal how risky it is in different operation. Until now, no weight was given to the questioning criteria, all of them were considered at the same level, and all assessments generally included subjective and verbal evaluations.

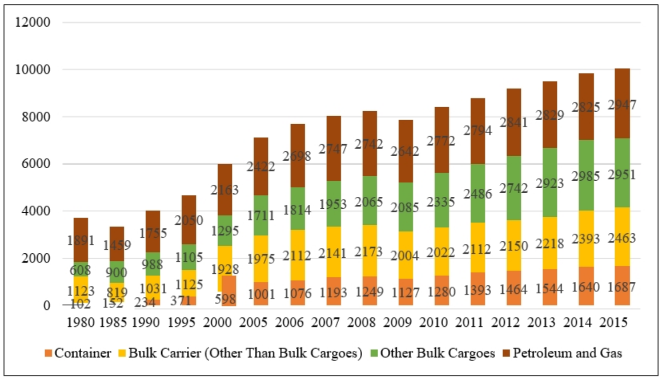
With the help of this study, it will be enabled that ship operators to eliminate deficiencies of vessels more effectively and efficiently. In addition, time and labor loss will be avoided by carrying out ship inspections with a scientific method.

2. Literature Survey

As in industry, profitability is the most important criteria in the maritime sector. In order to ensure the continuity of the profitability, the income and expense tables need to be calculated well. In order to obtain income, operations must be carried out in accordance with national and international rules and it is imperative to follow a cost strategy in accordance with these rules. In developed costing models, ship safety has a significant

[1]Prof. Dr., Uludag University, maltun@uludag.edu.tr.

Figure 1: International maritime transportation development.



Source: Authors.

impact. If a sample model is considered, it appears that the cost calculations are composed of the following main components (Enezy et al., 2017).

- Vessel Data
- Management Data
- Chartering Data
- Fixed Cost Components
- Voyage Parameters and Variable Cost Components

The safety and security requirements contained in the ship's data are essential components and reducing the measures of them leads to lower quality as well as bringing several risks together. The basic requirements to ensure the safety and security of ships are as follows (Urban'ski et al., 2008).

- To ensure that ships are constructed and equipped as required,
- To ensure that ships are prepared for sea operations,
- Providing basic navigation conditions for safe and secured operation of ships at sea,
- To ensure that ships can operate safely and securely at sea on their own,
- Equipping the vessels in danger with reliable alarm systems and provide assistance to them,
- Providing anti-terror security to ships and port facilities.

In today's literature, to determine the safety indicators of tankers; many factors such as human factor, safety management, navigation errors and natural conditions are presented (Wen-Kai et al., 2015). The human factor, one of these components, is one of the determining criteria of safety quality. Exploratory Factor Analysis (EFA) method has revealed three researcher factors that have been investigated on the human factor (Cordon et al., 2017).

- Group Capabilities: Tolerance, Empathy, Teamwork, Flexibility and Learning Willingness.
- Self-Knowledge: Initiative, Self-Confidence, Self-Control, Resilience, Responsibility and Calmness.
- Compliant and Ambitious Work, Rule-Based Adjustment, Motivation and Integrative Initiative.

The International Maritime Organization (IMO), for the ongoing developer policy, sets the technical requirements to prevent accidents and incidents that may occur on board. The technical requirements that cannot be fulfilled by the committees within IMO, are established in various organizations and put into practice in accordance with the rules of IMO.

3. Bridge Operations.

The systems on the bridge usually have been designed to be work independently so that a failure may occur in the equipment not to affect other devices. Although this criterion is very important, there are systems that need to be synchronized with each other on the bridge.

The maneuverability of the ships is influenced by many things both externally and internally. The external factors are; shallow waters, wind, current, wave, marine vehicles and land structures, while internal factors are; ship speed, boat structure, propeller and rudder system (Liu et al., 2015). The navigation process is divided into the following intermediate operations (Kopacz et al., 2003).

- Voyage planning,
- Steering, maneuvering and avoidance of danger,
- Following ship route and environmental conditions,
- Revision of the route and other necessary actions when necessary,
- Saving navigation data.

In this study, bridge operations will be reviewed under three main headings;

- Navigation Operations,
- Berthing / Unberthing Operations,
- Anchorage Operations.

Navigation operations are the operations whose risk factors is high due to the combination of many factors and negative consequences can cause major damages. It will lead to more accurate results by subdividing these operations into subcategories.

Depending on the size of the ships, it is not only the danger of grounding due to trim and squat, but also the loss of maneuvering characteristics as a result of the fluctuating hydrodynamic forces on the boat can lead to sea accidents (Lee and Hong, 2017).

Berthing, unberthing and ship to ship operations are among the most difficult and sensitive operations for large tanker operators (Oda et al., 2010). The speed of the vessel is one of the most important factor in such operations. The speed of the ship, which is determined by considering external factors such as wind, current, wave and depth, shall provide the safest maneuverability as indicated in the study of Roubos et al. (2017).

Criteria such as the structure of the anchor to be used, structure of the sea bottom, water depth, weather condition, sea condition and distance between the surrounding fixed objects & moving objects are affecting how and what way the anchorage operation is done.

4. Maritime Risks.

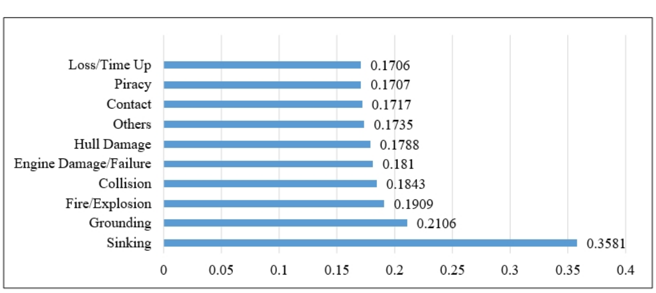
Risk management is the coordinated activities designed to control the risks that can prevent to achieve a successful outcome (Leveson, 2009). Risk management should be associated with the identification and strengthening of the conditions underlying the successful operation (Osiris et al., 2016). Maritime risky situations can be classified as follows:

- Hardware Risks,
- Risks of Navigation Operations,
- Berthing-Departure Operation Risks,
- Berthing Operations Risks,
- Risks of Bad Weather Events,
- Bad Marine Risks,
- Third Party Based Risk.

4.1. Root Cause Analysis for the Unsafe Conditions.

Nautical Institute over the past decade has investigated collisions and groundings that are linked to human error. In that study, it was revealed that 60 percent of events were directly related to human error and that a large proportion of these events were outside the Vessel Traffic Services (VTS) areas (Gale and Patraiko, 2007). According to a conducted survey, the rating of the factors leading to ship loss is shown in Figure 4.1 (Chen et al., 2017).

Figure 2: Rating of factors leading to ship loss.



Source: Authors.

The most common causes of human error in tanker operations are as follows (Altun et al., 2014):

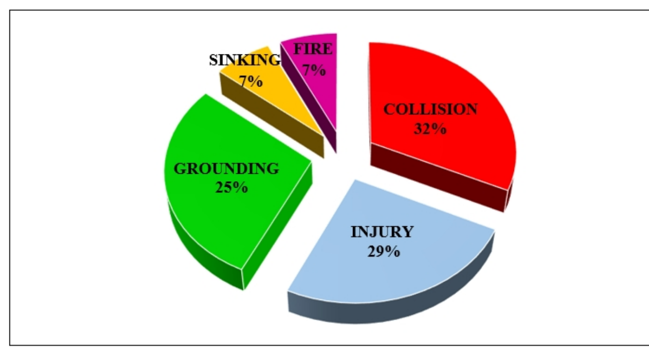
- Fatigue,
- Insufficient communication and coordination of the pilot and bridge personnel,
- Insufficient technical knowledge.

According to the standard international conventions regulating ship safety, there are five components in order to provide human safety at sea (Faturachman and Mustafa, 2012);

- Human Resources (requirements),
- Shipbuilding (requirements and equipment),
- Operation (operation of management personnel),
- External Factors (structural),
- Management and Coordination of the above Four Components.

The results of the incomplete communication are shown in Figure 3 as a maritime accident (Altun et al., 2014).

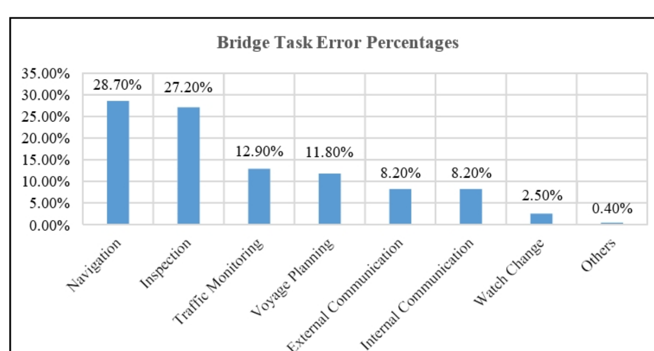
Figure 3: Incomplete communication results.



Source: Authors.

Most common mistakes made on the bridge are related with the navigation of ships. These mistakes include such as pilotage mistakes, lack of position of the ship, wrong maneuvering, misuse of electronic navigators and misunderstanding of other ship movements. The deficiencies related to the task error on the bridge are shown in Figure 4 (Graziano et al., 2016).

Figure 4: Deficiencies related to bridge task error.



Source: Authors.

While carrying hazardous materials, the implementation of various management strategies can reduce accidents significantly (Landucci et al., 2017). According to a conducted survey, the first three items under weighted safety leadership were found (Kim and Gausdal, 2017);

- Shared participation.
- Creation and configuration.
- Information.

4.2. *Factors Affecting Human Errors*

The root causes that are leading to the creation of unsafe situations including human errors, can be classified as follows;

The root causes that are leading to the creation of unsafe situations including human errors, can be classified as follows;

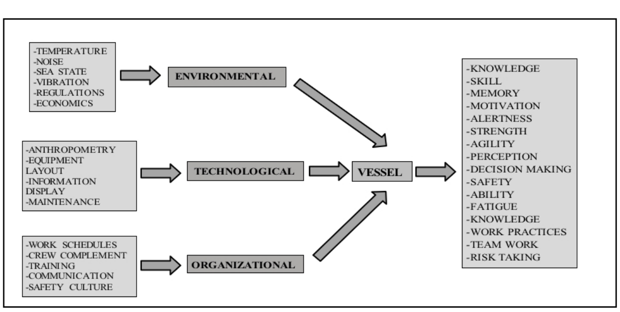
- Lack of familiarization or training.
- Lack of knowledge or talent.
- Equipment failure.
- Lack of monitoring.
- Management company faults.
- Third party faults.

The main factors affecting human errors can be classified into three topics. These topics are;

- Environmental.
- Technological.
- Organizational.

The factors affecting human errors and their components are shown in Figure 4.4 (Altun et al, 2014).

Figure 5: Factors affecting human errors.



Source: Authors.

5. Weighting of Inspection Deficiencies.

Weighing of the deficiencies were carried out with pairwise variable comparison data at the end of the questionnaire studies between ship master, first officer, deck officer and deck inspectors.

The Analytical Hierarchy Process (AHP) will be used as the weighting method developed by Saaty (1977). In addition, the data obtained by entering the Super Decisions program will be compared with the manually calculated data and the accuracy of the results will be determined.

In order to weight the deficiencies, the five source classes from which the ship's deficiencies originated are; Crew, Equipment, Company, Structure and International Safety Management.

Questionnaires were conducted between watchkeeping officers, chief mates, masters and deck inspectors to weight these sources. In this study, a pairwise comparison was made with the AHP method. According to the survey results, the following results were obtained.

The average of pairwise comparisions of watchkeeping officers is given in Table 1.

Table 1: Watchkeeping officer pairwise comparision results.

K1	Equipment	9	8	7	6	5	4	3	2	1	2	3	4	**5**	6	7	8	9	ISM
K2	Equipment	9	8	7	6	5	4	3	2	1	2	3	**4**	5	6	7	8	9	Crew
K3	Equipment	9	8	7	6	5	**4**	3	2	1	2	3	4	5	6	7	8	9	Structure
K4	Equipment	9	8	7	6	5	4	3	2	1	2	3	**4**	5	6	7	8	9	Company
K5	ISM	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Crew
K6	ISM	9	8	7	**6**	5	4	3	2	1	2	3	4	5	6	7	8	9	Structure
K7	ISM	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Company
K8	Crew	9	8	7	6	**5**	4	3	2	1	2	3	4	5	6	7	8	9	Structure
K9	Crew	9	8	7	6	5	4	3	**2**	1	2	3	4	5	6	7	8	9	Company
K10	Structure	9	8	7	6	5	4	3	2	1	2	3	4	**5**	6	7	8	9	Company

Source: Authors.

The average of the pairwise comparisons of the chief officers is given in Table 2.

Table 2: Chief officer pairwise comparision results.

K1	Equipment	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	ISM
K2	Equipment	9	8	7	6	5	4	3	2	1	2	3	4	**5**	6	7	8	9	Crew
K3	Equipment	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Structure
K4	Equipment	9	8	7	6	5	4	3	2	1	2	3	4	5	**6**	7	8	9	Company
K5	ISM	9	8	7	6	5	4	3	2	1	**2**	3	4	5	6	7	8	9	Crew
K6	ISM	9	8	7	6	5	**4**	3	2	1	2	3	4	5	6	7	8	9	Structure
K7	ISM	9	8	7	6	5	4	3	**2**	1	2	3	4	5	6	7	8	9	Company
K8	Crew	9	8	**7**	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Structure
K9	Crew	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Company
K10	Structure	9	8	7	6	5	4	3	2	1	2	3	**4**	5	6	7	8	9	Company

Source: Authors.

The average of the masters' pairwise comparisons are given in Table 3.

Table 3: Master pairwise comparision results.

K1	Equipment	9	8	7	6	5	4	3	2	1	**2**	3	4	5	6	7	8	9	ISM
K2	Equipment	9	8	7	6	5	4	3	2	1	**2**	3	4	5	6	7	8	9	Crew
K3	Equipment	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Structure
K4	Equipment	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	Company
K5	ISM	9	8	7	6	5	4	3	**2**	1	2	3	4	5	6	7	8	9	Crew
K6	ISM	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Structure
K7	ISM	9	8	7	6	5	4	3	2	1	**2**	3	4	5	6	7	8	9	Company
K8	Crew	9	8	7	6	5	**4**	3	2	1	2	3	4	5	6	7	8	9	Structure
K9	Crew	9	8	7	6	5	4	3	2	1	**2**	3	4	5	6	7	8	9	Company
K10	Structure	9	8	7	6	5	4	3	2	1	2	3	4	**5**	6	7	8	9	Company

Source: Authors.

The average of pairwise comparisons of company inspectors' are given in Table 4.

Table 4: Master pairwise comparision results.

K1	Equipment	9	8	7	6	5	4	3	2	1	2	3	4	**5**	6	7	8	9	ISM
K2	Equipment	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	Crew
K3	Equipment	9	8	7	6	5	4	3	**2**	1	2	3	4	5	6	7	8	9	Structure
K4	Equipment	9	8	7	6	5	4	3	2	1	2	3	4	**5**	6	7	8	9	Company
K5	ISM	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Crew
K6	ISM	9	8	7	6	5	**4**	3	2	1	2	3	4	5	6	7	8	9	Structure
K7	ISM	9	8	7	6	5	4	3	2	1	**2**	3	4	5	6	7	8	9	Company
K8	Crew	9	8	7	6	5	4	3	2	1	**2**	3	4	5	6	7	8	9	Structure
K9	Crew	9	8	7	6	5	4	3	2	1	**2**	3	4	5	6	7	8	9	Company
K10	Structure	9	8	7	6	5	4	3	2	1	**2**	3	4	5	6	7	8	9	Company

Source: Authors.

5.1. Calculation of Arithmetic Mean Values.

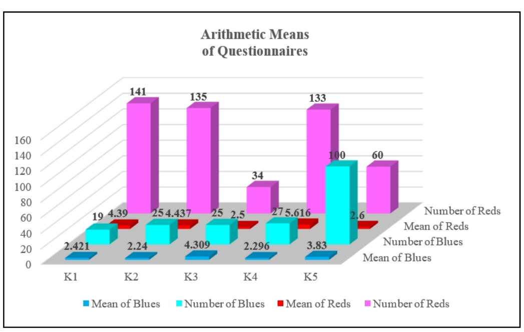
The arithmetic mean of pairwise comparisons are given in Table 5. Figures 6 and 7 show the arithmetic mean results of the questionnaires obtained from pairwise comparisons.

Table 5: Arithmetic mean of questionnaire results.

K1	Equipment	9	8	7	6	5	4	3	2	1	2	3	**4**	5	6	7	8	9	ISM
K2	Equipment	9	8	7	6	5	4	3	2	1	2	**3**	4	5	6	7	8	9	Crew
K3	Equipment	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Structure
K4	Equipment	9	8	7	6	5	4	3	2	1	2	3	**4**	5	6	7	8	9	Company
K5	ISM	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Crew
K6	ISM	9	8	7	6	5	4	**3**	2	1	2	3	4	5	6	7	8	9	Structure
K7	ISM	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Company
K8	Crew	9	8	7	6	**5**	4	3	2	1	2	3	4	5	6	7	8	9	Structure
K9	Crew	9	8	7	6	5	4	3	2	**1**	2	3	4	5	6	7	8	9	Company
K10	Structure	9	8	7	6	5	4	3	2	1	2	3	**4**	5	6	7	8	9	Company

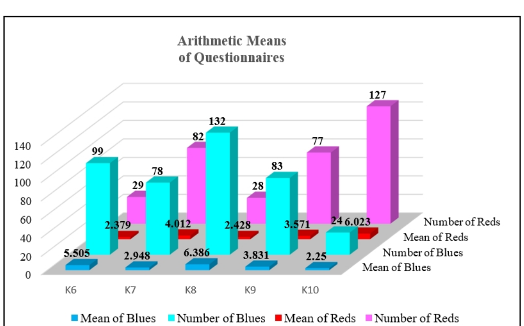
Source: Authors.

Figure 6: Arithmetic mean of questionnaire results 1.



Source: Authors.

Figure 7: Arithmetic mean of questionnaire results 2.



Source: Authors.

The arithmetic criterion weights according to the arithmetic average pairwise comparisons are calculated in Table 6 and Table 7.

Table 6: Arithmetic mean of AHP results.

	Crew	Equipment	ISM	Structure	Company
Crew	1.000	3.000	1.000	5.000	1.000
Equipment	0.333	1.000	0.250	3.000	0.250
ISM	1.000	4.000	1.000	3.000	1.000
Structure	0.200	0.333	0.333	1.000	0.250
Company	1.000	4.000	1.000	4.000	1.000
Total	3.533	12.333	3.583	16.000	3.500

Source: Authors.

Table 7: Arithmetic mean of AHP weights.

						Weights
Crew	0.283	0.243	0.279	0.313	0.286	0.281
Equipment	0.094	0.081	0.070	0.188	0.071	0.101
ISM	0.283	0.324	0.279	0.188	0.286	0.272
Structure	0.057	0.027	0.093	0.063	0.071	0.062
Company	0.283	0.324	0.279	0.250	0.286	0.284
Total	1.000	1.000	1.000	1.000	1.000	1.000

Source: Authors.

The arithmetic mean AHP inconsistency check was carried out in Table 8.

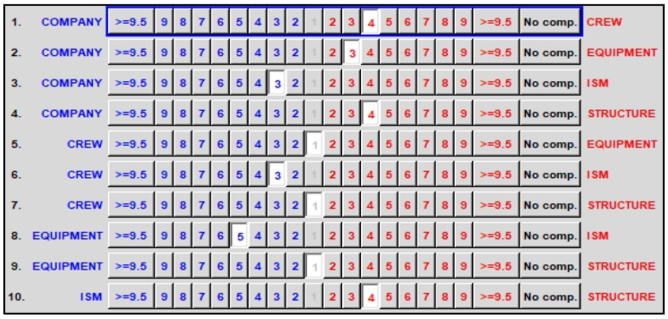
Table 8: Questionnaire arithmetic mean of AHP inconsistency check.

				n	RG
D Matrix		E Matrix		1	0
1.4501128		5.165889		2	0
0.5198304		5.155854		3	0.58
1.4267031		5.24667		4	0.9
0.3136143		5.048807		5	1.12
1.4888196		5.234481		6	1.24
				7	1.32
	λ =	5.17034		8	1.41
	n =	5		9	1.45
				10	1.49
	TG =	0.042585			
	TO =	0.038022			

Source: Authors.

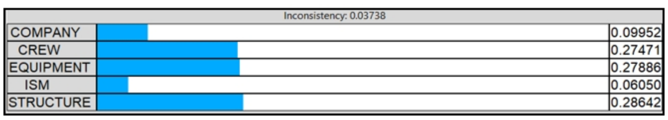
As a result of entering the data obtained by the arithmetic average of the questionnaires into the Super Decisions program, the images obtained are shown in Figures 8-11.

Figure 8: The arithmetic mean results of the surveys are shown in Super Decisions program.



Source: Authors.

Figure 9: Arithmetic mean of Questionnaire results Super Decisions program image 2.



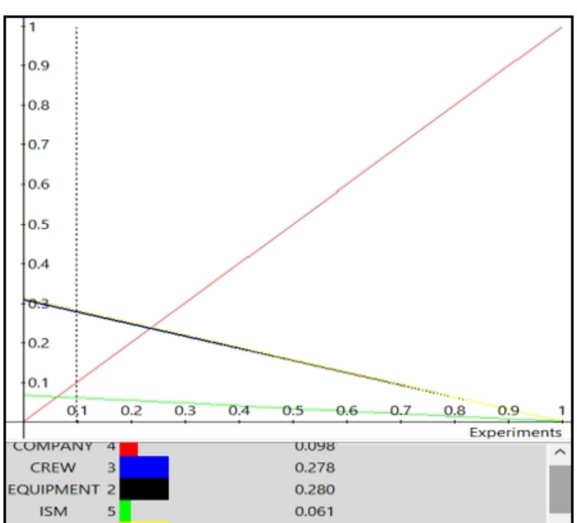
Source: Authors.

Figure 10: Arithmetic mean of Questionnaire results Super Decisions program image 3.

Name	Graphic	Ideals	Normals	Raw
COMPANY		0.351976	0.099508	0.099508
CREW		0.982538	0.277776	0.277776
EQUIPMENT		0.988559	0.279478	0.279478
ISM		0.214087	0.060525	0.060525
STRUCTURE		1.000000	0.282713	0.282713

Source: Authors.

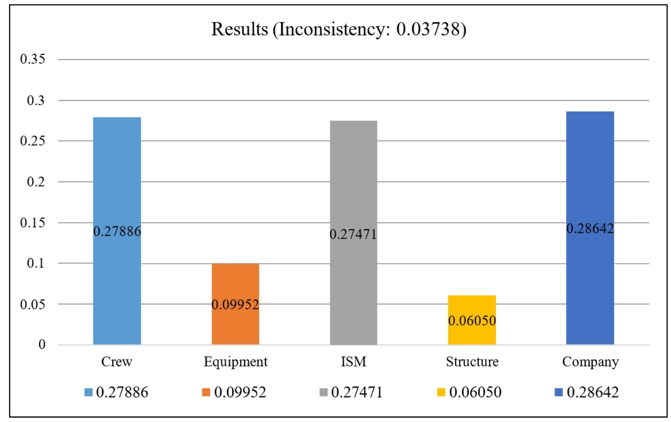
Figure 11: Arithmetic mean of Questionnaire results Super Decisions program image 4.



Source: Authors.

The graphical representation of AHP weights according to the arithmetic mean survey results is as shown in Figure 12.

Figure 12: Arithmetic mean of questionnaire AHP weights.



Source: Authors.

Conclusions.

The following conclusions were reached when the arithmetic mean of the pairwise comparisons in the questionnaire studies were obtained during the studies:

- The ISM criterion has 4th degree superiority over the equipment criterion. This suggests that there is an opinion among mariners that the right equipment at the ship is available through the ISM system.
- The crew criterion has 3rd degree superiority over the equipment criterion. This is an indication of the determinant role of staffing criteria following the ISM criteria in providing the correct equipment.
- The structural criterion has 3rd degree superiority over the equipment criterion. Due to the difficult and restricted replacement of structural components, it increases the equipment criterion role importance and it is more important to mariners.
- The company's criteria has 4th degree superiority over the equipment criterion. There is always a pressure on the company due to the responsibility element and is regarded as a superior criterion for the right equipment provided by mariners.
- There seems to be no superiority between ISM and the company. No distinction can be made as the management company factor is one of the leading factors in the development and implementation of the ISM.
- ISM criteria has 3rd degree superiority over the structural criteria. As mentioned earlier, the difficulty of changing the structural component and the determination of the structural criteria in the ISM direction makes this criterion more important.

Table 9: The best scenario crew technical score.

RANK	Capt.	Chief Off.	2nd Off.	3rd Off.	4th Off.	Chief Off.	2nd Eng.	3rd Eng.	4th Eng.
Total Service Time for Current Company	50	50	50	50	50	50	50	50	50
Total Service Time for Current Rank	50	50	50	50	50	50	50	50	50
Total Service Time for Current Type of Tankers	50	50	50	50	50	50	50	50	50
Total Service Time for All Types of Tankers	50	50	50	50	50	50	50	50	50
Total Service Time for the Current Tanker	50	50	50	50	50	50	50	50	50
Total Sea Service Time	50	50	50	50	50	50	50	50	50
Education Level	4	4	4	4	4	4	4	4	4
Vessel Detentions During Working Periods	10	10	10	10	10	10	10	10	10
	578.659	578.659	578.659	578.659	578.659	578.659	578.659	578.659	578.659
	675.102	675.102	675.102	675.102	675.102	675.102	675.102	675.102	675.102
	721.111	721.111	721.111	721.111	721.111	721.111	721.111	721.111	721.111
	691.028	691.028	691.028	691.028	691.028	691.028	691.028	691.028	691.028
	555.654	555.654	555.654	555.654	555.654	555.654	555.654	555.654	555.654
	734.383	734.383	734.383	734.383	734.383	734.383	734.383	734.383	734.383
	42.824	42.824	42.824	42.824	42.824	42.824	42.824	42.824	42.824
	101.752	101.752	101.752	101.752	101.752	101.752	101.752	101.752	101.752
	512.564	**512.564**	**512.564**	**512.564**	**512.564**	**512.564**	**512.564**	**512.564**	**512.564**
Crew Score = 512.564									

Source: Authors.

Table 10: Crew scoring criteria weights.

No	Criteria	Weight
1	Total Service Time for Current Company	6.54
2	Total Service Time for Current Rank	7.63
3	Total Service Time for Current Type of Tankers	8.15
4	Total Service Time for All Types of Tankers	7.81
5	Total Service Time for the Current Tanker	6.28
6	Total Sea Service Time	8.30
7	Education Level	6.05
8	Vessel Detentions During Working Periods	5.75

Source: Authors.

- It seems that there is no superiority between ISM and company criterias.

  Establishment and implementation of the ISM depends directly on the human factor and determining any superiority between them may bring other problems.

- Personnel criterion has 5th degree superiority over the structural criteria. The greatest superiority established in pairwise comparisons is this comparison. When the ship's components and equipment are considered to provide certain standards, their proper use of them seems to depend directly on the ship's crew. This situation is a reflection of the importance of working with qualified personnel.

- Personnel and company criterias do not have any advantage over each other. No superiority was determined because the greatest factor for choosing the crew of the ship and proper ISM applications are being seen as the company.

- It is seen that the structural criteria has 4th degree superiority over the company criteria. This is an indication of the importance of decisions made by the management company, which has the final say in the construction and during dry dock periods of the ships.

- After weighting all componentes of a vessel, crew scoring model has been created. The best scenario technical point for crew is shown in Table 9. Equipment, ISM, structure and company scoring models could be created as well as the crew scoring model.

- A questionnaire were carried out for weighting crew scoring criteria. The results of this questionnaire is shown in Table 10.

- There are eight criteria were examined during the crew scoring modal. According to best crew score scenario, it was assumed that 50 years of experience for all crew members in total service time for current company, total service time for current rank, total service time for current type of tankers, total service time for all types of tankers, total service time for the current tanker and total sea service time.

- The education level for all crew members were assumed as a doctorate level. As the last criteria, vessel detentions during working periods are assumed as zero detentions during the last three years.

- The maximum crew score has been calculated as 512.564 by crew scoring modal. This modal can be applied to all criteria which are related with vessel inspections.

References

Altun, M. H. A., Kum, S. & Cicek, I. (2014). IAMU Conference 15AGA. Human Errors on Chemical Tanker Loading-Discharging Operations. Proceeding of Innovation in Maritime Education, Training and Research, International Association of Maritime Universities, Tasmania, Australia. 27-30 October.

Chen, J., Zhanga, F, Yanga, C., Zhanga, C. & Luoa, L. (2017). Factor and Trend Analysis of Total-loss Marine Casualty Using a Fuzzy Matter Element Method. *International Journal of Disaster Risk Reduction 24:* 383-390.

Cordon, J. R., Mestre, J. M. & Walliser, J. (2017). Human Factors in Seafaring: The Role of Situation Awareness. *Safety Science 93:* 256-265.

Deniz Ticareti 2015 Istatistikleri. (2015). Ulastirma Denizcilik ve Haberlesme Bakanligi, Deniz Ticareti Genel Mudurlugu, Ankara.

Enezy, O. A., Hassel, E., Sys, C. & Vanelslander, T. (2017). Developing a Cost Calculation Model for Inland Navigation. *Research in Transportation Business & Management 23:* 64-74.

Faturachmana, D. & Mustafa, S. (2012). Performance of Safety Sea Transportation.

Procedia - Social and Behavioral Sciences 57: 368-372.

Gale, H. & Patraiko, D. (2007). The role of e-navigation. *Improving Navigational Safety,* Seaways, July 2007, Page 4-8.

Graziano, A., Teixeira, A. P. & Soares, C. G. (2016). Classification of Human Errors in Grounding and Collision Accidents Using the Tracer Taxonomy. *Safety Science 86:* 245-257.

Kim, T. & Gausdal, A. H. (2017). Leading for Safety: A Weighted Safety Leadership Model in Shipping. *Reliability Engineering and System Safety 165:* 458-466.

Kopacz, Z., Morgas, W. & Urban'ski, J. (2003). The Ship's Navigation Function, Ship's Navigation Processes, and Ship's Navigational Information. The Royal Institute of Navigation. *The Journal of Navigation 56:* 101-109.

Landucci, G., Antonioni, G., Tugnoli, A., Bonvicini, S., Molag, M. & Cozzani, V. (2017). Hazmat Transportation Risk Assessment: A Revisitation in the Perspective of the Viareggio LPG Accident. *Journal of Loss Prevention in the Process Industries 49:* 36- 46.

Lee, S. & Hong, C. (2017). Study on the Course Stability of Very Large Vessels in Shallow Water Using CFD. *Ocean Engineering 145:* 395-405.

Leveson, N. G. (2011). *Engineering a Safer World.* Aeronautics and Astronautics and Engineering System Division, Massachusetts Institute of Technology. MIT Press.

Li, K. X., Yin, J. & Fan, L. (2014). Ship Safety Index. *Transportation Research Part A66:*pp. 75-87.

Moreira, L., Fossen, T. I. & Soares, C. G. (2007). Path Following Control System for a Tanker Ship Model. *Ocean Engineering 34:* 2074-2085.

Oda, H., Okuyama, E. & Shimizu, E. (2010). Ship to Ship Operations Monitoring System Using High Accuracy DGPS. *8th IFAC Conference on Control Applications in Marine Systems, (pp. 62-66).* Rostock-Warnemunde, Germany, September 15-17.

Osiris, A. V. B., Floris, G., Vladimir K., Pentti, K., & Jakub, M. (2016). Risk Management Model of Winter Navigation Operations. *Marine Pollution Bulletin 108:* 242-262.

Review of Marine Transport. (2016). *United Nations Conference On Trade and Development (UNCTAD)*, United Nations, ISBN 978-92-1-112904-5. New York and Geneva.

Roubos, A., Groenewegen, L. & Peters, D. J. (2017). Berthing Velocity of Large Seagoing Vessels in the Port of Rotterdam. *Marine Structures 51:* 202-219.

Saaty, T. L. (1977). Scaling Method for Priorities in Hierarchical Structures. *Journal of Mathematical Psychology,* 15(3): 234-281.

Tarelko, W. (2012). Origins of Ship Safety Requirements Formulated by International Maritime Organization, 2012 International Symposium on Safety Science and Technology. *Procedia Engineering 45:* 847-856.

Urbanski, J., Morgas, W., & Kopacz, Z. (2008). The Safety and Security Systems of Maritime Navigation. *The Journal of Navigation 61:* 529-535.

Wen-Kai K. H., Huang, S. H. S. & Yeh, R. F. J. (2015). An assessment model of safety factors for product tankers in coastal shipping. *Safety Science 76:* 74-81.