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IAMU 2018 Research Project
(No. YAS201806)

Development of Standard Accident / Incident Analysis Forms Improvement of safety in maritime accident investigation

By

Istanbul Technical University, Faculty of Maritime (Contractor)

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TEL : 81-3-6257-1812 E-mail : info@iamu-edu.org URL : http://www.iamu-edu.org

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Contractor : Oğuz Salim Söğut, ITU-MF
Research Coordinator : Tuba KECECI, ITU-MF
Research Partner : Veysel GOKCEK, ITU-MF

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Istanbul Technical University, Faculty of Maritime (Contractor)

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Research Coordinator, Tuba KECECI

Tuba KECECI

Assistant Professor, Istanbul Technical University, Faculty of Maritime, kececit@itu.edu.tr

Veysel GOKCEK

Research Assistant, Istanbul Technical University, Faculty of Maritime, gokcekv@itu.edu.tr

Abstract

The hazardous structure of onboard operations makes the existence of dangerous occurrences unavoidable, which might substantially damage human life, the environment, and also the commodity. In accordance with IMO requirements, to prevent accidents or to minimize their impacts, all marine accidents/incidents should be reported and analyzed without any delay. Through investigating ship accidents, it is aimed to determine the root causes that cause hazardous situation and to implement appropriate corrective and preventive actions. The analysis is carried out according to the procedures of shipping companies. However, the structure of the analysis forms used by shipping companies is quite different from each other. To demonstrate this situation, the structure of analysis forms used by different international shipping companies were reviewed. While some shipping companies use a form as short as one page which is not satisfying for in depth analysis of complex marine accidents, some shipping companies use forms designed in detail.

To bring an improvement in accident investigation, standardization in the analysis of accident/incident & near miss is a need. In this project, it is aimed to fit the structure of existing maritime accident/incident analysis &reporting forms to a standard to enable standardization. Within the scope of this research, international regulations and standards on accident/incident analysis were examined. Shipping company procedures were reviewed and a literature review was conducted. The needs of the maritime sector tried to be captured by holding workshops, and a standard accident/incident and near miss analysis and reporting form was developed. Study results were validated both by expert-judgment validation method and by case study application. This research will be a novel study in which current ship accident analysis forms were put into a standardized format. It will contribute to improving safety culture in the maritime sector.

Keyword: *Marine Accident, accident analysis, safety, standardization*

Executive Summary

One of the essential concerns in the maritime sector is to increase safety and to reduce pollution caused by ship accidents and incidents, as we know that disastrous maritime accidents can cause significant damage to the economy, human life, and the environment. It is not possible to eliminate maritime accidents according to the unique structure of work environment, whereas a major objective is to reduce accidents, to reduce the likelihood of accidents and minimize the severity of the associated results. Thus, to increase safety and to protect the marine environment better by avoiding repetition, it is of great importance to investigate the ship accidents by experts and to deliver the outputs to the authorities.

In order to prevent or minimize accidents, all marine accidents/incidents should be reported and analyzed without delay under IMO regulations. It is aimed to determine the root causes for applying appropriate strategic actions in order to prevent recurrence by investigating ship accidents. The analysis in this project follows the procedures of shipping companies. In addition to that, the structure of the analysis forms used by shipping companies varies considerably. To illustrate this situation, the structure of the analysis forms used by various international shipping companies were reviewed. While some shipping companies use a short form that is not satisfactory for in-depth analysis of complex marine accidents, some maritime shipping companies use elaborate forms. Besides, each company uses different techniques for root cause analysis of ship accidents and does not have a standard taxonomy used in the maritime domain.

Facilitation is needed regarding standardization of root cause taxonomy in occurrence reporting, follow-up, and improvement in the analysis. In order to establish a common approach to safety, it is considered that a standard root cause terminology list should be developed for use in the analysis section of the standard form.

In this project, we proposed an accident/incident and near-miss analysis & reporting form which is not designed for a specific ship type or ship operation. This form is proposed to be used by shipping companies for internal use and it is not the reporting form that is used by the maritime authorities. It was structured to easy to implement with new standards and regulations. To improve project outcomes in the maritime domain, two workshops were held. A network for the working group of shipping companies operating different types of ships in international waters was established. Oceangoing masters from General Directorate of Coastal Safety were also invited to the network. A Member from Turkish Accident Investigation Board joined the group in order to improve our research results. In addition, a sub-working group was established.

A literature review was applied, including the paper which was extracted from the project coordinator's Ph.D. thesis, and accident investigation boards' recent investigation reports during the taxonomy development process. The ships listed in the reports reviewed had different types and sizes. In addition, the accident analysis forms of eleven shipping companies were examined. The root causes in the forms were identified and recorded. All of the resources mentioned above were analyzed to form a list of root causes. Based on the expert opinion, a new root cause evaluation taxonomy was developed. Developed root cause evaluation taxonomy was validated by the project staff. For every category and root cause, there's a unique "ID" code to make it easy to cite, 'H' for human factors and 'J' for Job-related factors. Human-related root causes were grouped under six main headings. These are Human Behaviour, Human Characteristics, Physical/Physiological Capacity-Stress, Psychological Capacity-Stress, Inadequate Knowledge, Skill, Training, and Factors for Lack of Motivation, respectively. Job-related root causes were grouped under eleven main headings. These are Communication Problems, Inadequate Leadership, Inadequate Team Culture, Safety-Related Issues, Inadequate Manning Level, Problems Related to System and/or Its Application, Inadequacy in Ship Construction, Design and Equipment, Cargo-

Related Issues, Environmental Factors, Third-Party Related Factors, and Commercial Pressure, respectively.

At the beginning of the project studies, we decided to develop an analysis form for accident and incident cases. However, by reviewing the output of workshops, the need for a proactive approach arise. So we included the near-miss event to the project studies. The company representative suggested to combine analysis and reporting forms and an accident/incident and near-miss analysis & reporting form structure was designed.

Following, the final version of the standard analysis & reporting form was generated and validated upon applying in maritime accident/incidents and through the expert-judgment validation method. In order to finalize the developed analysis & reporting form, the Delphi method in which the level of the experts' agreement was calculated using the Fleiss Kappa statistic and shown by Kappa value.

After the validation step, a guideline containing information regarding the standard form was prepared.

This project will serve as a novel example to fit existing maritime accident/incident analysis to a certain standard. All the work carried out in this study will contribute to the development of safety culture in the maritime domain.

1. Introduction

Technology is used to create enhanced systems for mitigating risk at sea; however, it is also reducing the number of seafarers on board. It brings us to face an irony that while technological advancement assists seafarers, it causes more workload for each seafarer. If we consider that human error is the primary contributing factor to ship accidents [1], technological advancement will trigger more accidents in the short term. Besides, the number of vessels in the world merchant fleet is constantly growing year by year, as seen in Fig. 1 [2]. This continuous growth with reduced manning level and complex structure of onboard operations can increase the occurrence of maritime accidents and incidents. Despite the various implementations on rules, regulations, training, and management aimed to improve safety, shipping accidents and incidents remain a major concern.

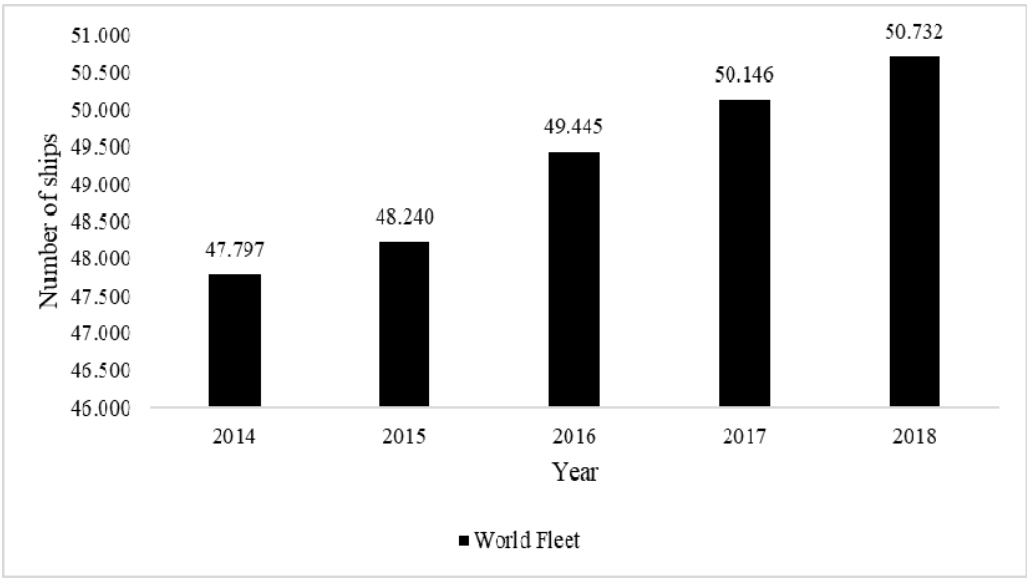

Fig. 1. World merchant fleet number year by year [2].

As per the statistics issued by European Marine Casualty Information Platform [3], while the number of fatalities, very serious casualty and the ship lost decreases, the total number of maritime casualties and the number of injuries remain same over time as shown in Fig. 2.

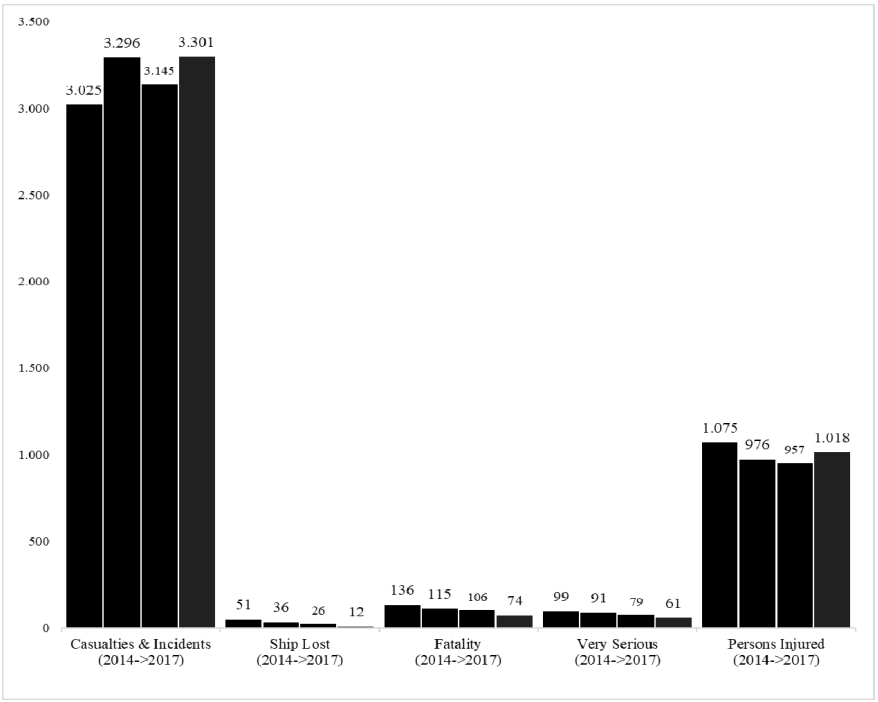

Fig. 2. EMCIP casualty statistics [3]**.**

This situation also appears in the statistics of Japan Transportation Safety Board (JTSB) [4]. Fig. 3 shows that there is not a significant decrease in the number of incidents and accidents reported to JTSB.

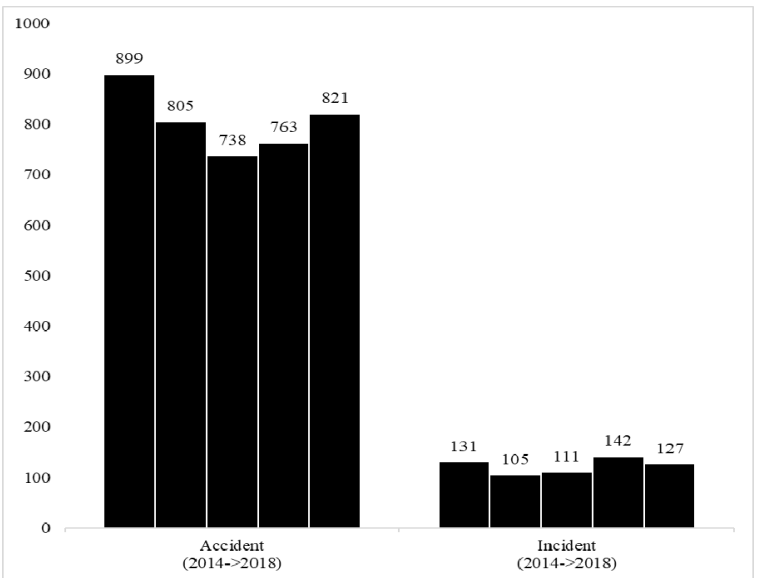

Fig. 3. JTSB casualty statistics [4]**.**

Considering the fact that since there has been increasing attention and awareness on reporting the accidents and incidents, we should also expect to increase in the number of reports year by year. Therefore, those slight decreases in the number of reports instead of increasing, show us improvements achieved by producing preventive actions in the maritime safety-related issues. However, we know that shipping accidents may cause catastrophic results such as pollution, death, and crisis, there should be more enhancements to improving safety and reducing accident risk which is one of the main concern in the maritime industry. Totally eliminating shipping accidents seems impossible; however, mitigating risks by analyzing accidents is a reasonable target to decrease the probability of accident occurrence. This can also minimize the severity of the relevant consequences. Thus, to protect lives and environment, and to enhance safety by preventing a recurrence, every ship accidents should be investigated by the experts in the standardized form to enable safe data exchange [5] between expanding world merchant fleet. This standardization may lead to more decreases in the occurrence rate of any accidents in the future.

Investigating ship accidents is not a new idea that United Nations Convention on the Law of the Sea (UNCLOS) article 94, paragraph 7 keeps responsible the flag state for investigation ship accidents under certain conditions such as involving a ship flying its flag [6]. This obligation reporting ship accident for each administration is also mentioned in SOLAS regulation I/21, regulation XI-1/6, MARPOL Convention article 12, Load Lines Convention article 23 and ILO Convention No.134 article 2.

Beside of those conventions and regulations, there are resolutions published by International Maritime Organization (IMO) on the issue of maritime casualty investigation. As a combination and an expansion of previous resolutions requiring a marine safety investigation, IMO published Code of International Standards and Recommended Practices for a Safety Investigation into a Marine Casualty or Marine Incident (Casualty Investigation Code). The Code aims to create a common approach in maritime casualty investigation, to expand investigation procedures and to require reporting accident/incident records and statistics to the organization. Those requirements are standardized by introducing Maritime Casualties and Incidents (MCI) module in Global Integrated Shipping Information System (GISIS). GISIS-MCI module is the most significant database to access the ship accident investigation reports among various databases.

GISIS-MCI module creates a common information flow system which records accident investigations in a standardized format. This system increases attention on reporting accidents and enables to conduct further reliable analyses by using the identical format of the reports uploaded by state parties [5]. However, this standardization is only for authorities which are investigating ship accidents involving the ships carrying their state's flag or accidents having occurred in their territorial waters [5].

According to the ISM code, there should be procedures for reporting non-conformities, accidents, and hazardous situations on-board to the shipping company with the objective of improving safety and pollution prevention [7]. In order to perform this task, the company should include accident/incident analysis form in its Safety Management System (SMS). This form should allow safe data exchange not only between the company's fleet but also between companies to share their outcomes and taken actions for preventing recurrence of the same type of accidents. However, the format and details of accident/incident analysis forms are quite different from each other and do not have a standard structure.

In order to reveal this non-standard condition, we examined eleven international shipping companies' accident/incident analysis forms. It was found that some of the forms are only just one page in length with open-ended questions which is not suitable to investigate marine accidents comprehensively. On the other hand, some of them were designed in detail and used both open-ended and closed-ended questions. So as to move one step further in accident investigation, we realized that standardization of accidents/incidents analysis forms is necessary just as the case in the standardization of the accident reporting system [5].

For this purpose, we focus on developing a standard form for company accidents/incident analysis in this research. The developed form is designed generally for all ship types and ship operations. It has a structure which can easily be kept up to date by new standards and regulations.

1.1 Objectives

The objective of this project is listed as follows:

1. Reviewing relevant academic literature and examining international standards on ship accident/incident analysis in order to find research gaps.
2. Establishing a working group of eleven maritime companies' representatives operating a different type of ships in international waters.
3. Examining of accident/incident analysis forms gathered from the established working group
4. Conducting two workshops to discuss issues about developing standardized accident/incident analysis form.
5. Creating standardized accident/incident analysis & reporting form with validation study, and its guidelines with example.

1.2 Structure of the report

This report is divided into 5 sections. Each section gives information about those topics:

- **Section one** introduces the importance of standardization on ship accident/incident analysis by discussing the present condition and relevant regulations.
- **Section two** provides a literature review in both academic and regulatory perspective in order to find research gaps.
- **Section three** is to report results with the discussion within six sub-section. Sub-section 1 informs followed methodology to conduct this research. Sub-section 2 and 3 is about taxonomy developments and its validation. Sub-section 4 shows the development process of standardized accident/incident analysis form. Sub-section 5 and 6 define guidelines for developed form and its example study.
- **Section four** consists of conclusions and recommendations
- **Section five** includes attachments

2. Background and Literature Review

In order to reveal gaps in the research topic, we have conducted detailed literature review both in academic and in regulatory perspective. In academic literature, we tried to understand developed models for accident/incidents analysis, which can lead us to create proper taxonomy. We used this taxonomy in our standardized form to enable safety data exchange and focus on common safety issues. After deciding the proper approach for taxonomy, we reviewed rules and regulations in order to find gaps in accident/incident analysis systems. Finally, we discussed found gaps in the Research Gap section.

2.1 Academic Researches

There are several types of research studied on establishing the best suitable model to analyze marine accidents. Some of them focused on human errors while some included system-related factors which are not directly connected with the human factor. Rasmussen's [8] Skill-Rule-Knowledge based error taxonomy and Reason's [9] Generic Error Modelling System (GEMS) were designed for individual human errors, while Reason's [10] Swiss Cheese Model (SCM) and Hawkins's SHELL [11] model took into account systemic and organizational errors beside of individual errors. Those models were developed to prevent reoccurrence with same causes by revealing underlying factors of the accident.

The SHELL model is based on the human element and its connection with other resources. The S (software), H (hardware), E (environment), and L (liveware) modules are interacted with the central L module to provide areas for human factors analysis. SHELL model evaluates the only effect of four components on a person rather than its components themselves. It does not cover all interfaces which are outside human factors such as Hardware-Environment, Environment-Software [12]. SCM is used as a fundamental structure for maritime risk assessment models.

The Human Factors Analysis and Classification System (HFACS) and Systemic Occurrence Analysis Methodology (SOAM) were created by inspiring previously developed models, especially SCM [13]. SOAM uses both inter-relationships between all contributing factors (SCM) and connections of all factors to one responsible person which is directly related to the safety of process (SHELL). On the other hand, HFACS tries to extract active failures and latent conditions at different levels such as unsafe acts, preconditions, unsafe supervision, and organizational influents [14] for adopting the IMO's approach for investigating and analyzing human factors involved in marine casualties and incidents. Taxonomy created by HFACS approach is utilized for various models on maritime accident analysis. Analytical HFACS [15], HFACS-MSS [16], and HFACS-Maritime Accidents (HFACS-MA) [17] are examples of those models which are developed for analyzing human and organizational factors in ship accidents. However, the reliability of HFACS is questioned in the literature [18].

In addition to the mentioned methods above, there are root cause-based analysis techniques in the literature. Root causes explain the reason why the accident occurs. In other words, if the root causes of certain accident do not exist, such an accident does not occur. Thus, gathering root causes from existing ship accident reports can lead us to create proper taxonomy which can propose preventing actions to eliminate reoccurrence of accidents. It can also create a common data exchange platform between companies. Events and Causal Factors Charting (ECFC), 5-Whys, Cause, , Event Tree Analysis (ETA), Fault Tree Analysis (FTA), Cause & Effect Diagram (CED), Systematic Cause Analysis Technique (SCAT) and Ship Accident Root Cause Evaluation (SHARE) [5], [19], [20] are the example of root cause analysis. Among them, SHARE is the newest one and standard technique utilized in accident/incident analysis. SHARE was created by considering maritime company databases, ship accident investigation reports, and commercial software programs such as M-SCAT and Marine Root Cause Analysis Technique (MaRCAT). By utilizing relevant updates and enhancements, this approach is useful to create proper taxonomy in this research. Review of previous research is given in Table 1.

Table 1. Review of previous research

Reference	Technique	Focus/Application
Rasmussen, (1982) [8]	Skill-Rule-Knowledge based error taxonomy	Individual human errors
Reason, (1990) [9]	Generic Error Modelling System (GEMS)	Individual human errors
Reason, (2016) [10]	Swiss Cheese Model (SCM)	Including systemic and organizational errors
Hawkins, (2017) [11]	SHELL model	Including systemic and organizational errors
Chen, et. al. (2013). [13]	HFACS-MA	HFACS analogy for marine casualty investigation and analysis
Celik and Cebi, (2009) [15]	Analytical HFACS	Analytical Human Factors Analysis and Classification System (HFACS), based on a Fuzzy Analytical Hierarchy Process (FAHP)
Schröder-Hinrichs et. al. (2011) [16]	HFACS-MSS	(HFACS) with minor modifications related to machinery space features
Chen and Chou, (2012) [17]	HFACS-MA	Incorporates HFACS-MA with Why-Because Analysis
Kececi and Arslan (2017) [5]	Ship Accident Root Cause Evaluation (SHARE)	A novel approach to marine accident root cause analysis by using Fuzzy SWOT AHP

2.2 International Rules, Regulations and Standards

Investigating ship accidents by administration is stated under article 94 on Duties of the flag State in UNCLOS as “Each State shall cause an inquiry to be held by or before a suitably qualified person or persons into every marine casualty or incident of navigation on the high seas involving a ship flying its flag and causing loss of life or serious injury to nationals of another State or serious damage to ships or installations of another State or to the marine environment” [6]. In parallel with UNCLOS, SOLAS regulation I/21, MARPOL Convention article 12, Load Lines Convention article 23 and ILO Convention No.134 article 2 require the investigation of ship accident/incidents by administrations.

Besides, A/ES.IV/Res.173 is the first resolution published by IMO about maritime casualty investigation. It ensures that the administration shall be represented at inquiries if the consequences of a casualty are affecting their coasts [21]. The second resolution A.322(IX) requests “Administration to give information regarding the inquiries held into them and their findings and thereafter to take any appropriate action to this end” [22]. Resolution A.440(XI), A.442(XI) and A.637(16) emphasize lack of information exchange between administrations and urge governments to cooperate maritime casualty investigations together and to exchange information freely by aiming comprehensive evaluation of casualties [23]–[25]. Resolution A.849(20), *revoking A.173(ES.IV), A.440(XI) and A.637(16),* ensures that flag States are required to investigate all very serious and serious maritime casualties and to share all outcomes with the Organization [26]. Resolution A.884(21), *amendments to A.849(20)*, is aimed to provide guidelines for investigating the human factor in maritime casualties [1]. As a combination and an expansion of mentioned resolutions, resolution MSC.255(84), *Code of International Standards and Recommended Practices for a Safety Investigation into a Marine*

Casualty or Marine Incident (Casualty Investigation Code), was published in May 2008 [27]. It includes relevant amendments to SOLAS Chapter XI-1. Those amendments are to make mandatory of parts I, *General provisions*, and part II, *Mandatory standards*, of Casualty Investigation Code (CIC) [27]. This code requires that "each flag State has a duty to conduct an investigation into any casualty occurring to any of its ships, when it judges that such an investigation may assist in determining what changes in the present regulations may be desirable, or if such a casualty has produced a major deleterious effect upon the environment" [27].

Besides, it requires that "a marine safety investigation shall be conducted into every very serious marine casualty" [27]. Very serious marine casualty means "a marine casualty involving the total loss of the ship or death or severe damage to the environment" [27]. This obligation is for clarifying and bordering judgments of flag State to investigate ship accidents.

Resolution A.1075(28), *revoking resolutions A.849(20) and A.884(21),* aims to assist CIC and provides a common approach to administrations for investigation of marine accidents [28]. Fig.4 shows the timeline for all mentioned resolutions.

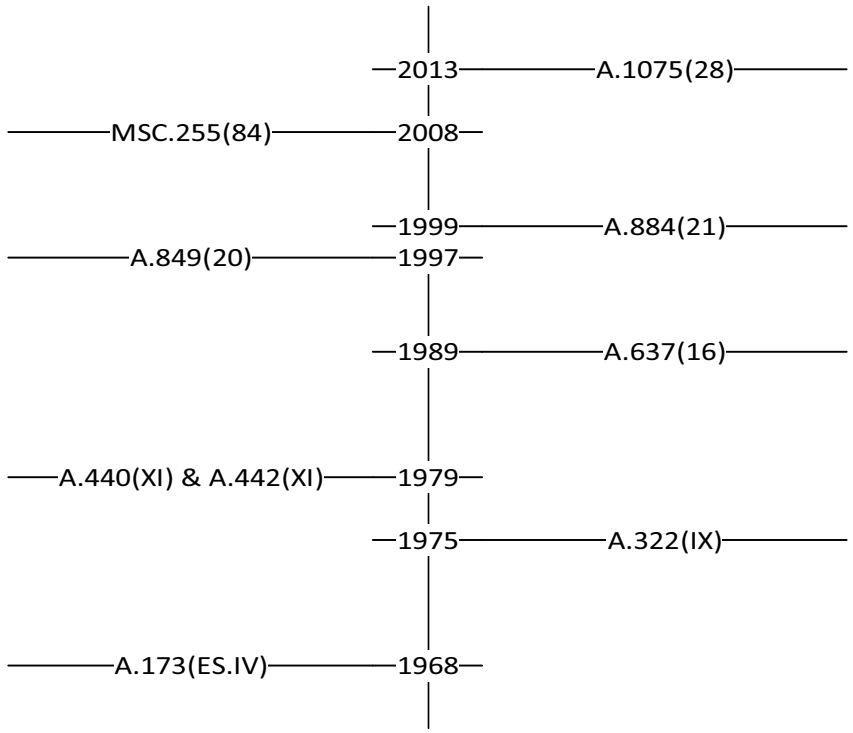

Fig. 4. Timeline for casualty investigation related resolutions

IMO also published a document, *Casualty Analysis Procedure*, to define the process of casualty investigation analysis reports and procedures for assessing safety issues. It also includes flow chart for casualty information, validating safety issue process, estimated risk level assignment, and diagram for casualty analysis process [29].

In parallel with these publications, MCI module was included in GISIS in order to create a common information flow system for accident investigation reports. GISIS-MCI module, whose required format is defined in MSC-MEPC.3/Circ.3 [30], includes all casualty analyses approved by the FSI Sub-Committee and lessons learned from reports approved by the III Sub-Committee [31]. Those are circulated to seafarers in order to increase the awareness of accidents for prevention purposes. However, standardization of reporting format is only for authorities and accident investigation boards

investigating ship accidents involving the ships carrying their state's flag or accidents having occurred in their territorial waters.

On the other hand, The ISM code holds the company responsible for creating an analysis procedure for non–conformities, accidents, and hazardous occurrences and include them in their SMS [7]. These non-conformities, observations and hazardous occurrences should be reported to the responsible person of the management, and there should be a system in place for recording, investigating, evaluating, reviewing and analyzing such reports, in order to take appropriate corrective actions and to ensure that recurrence is avoided [7]. The evaluation of reports may result in:

- Appropriate corrective actions;
- Amendments to existing procedures and instructions; and
- Development of new procedures and instructions [7].

Analyzing occurred accidents and taking necessary actions mentioned above can lead us to take corrective actions to prevent reoccurrence of the same accidents or incidents. This is the reactive approach to improve safety. On the other hand, one can also infer proactive actions by analyzing non-conformities and near-misses, which is an event that could have resulted in injury, damage to property, or the environment under slightly different circumstances. Therefore, the ISM code also mentions that 'the company should encourage the reporting of near misses to maintain and improve safety awareness [7]. It also emphasizes that "the reporting and analysis of such events are essential for an effective risk assessment by the company, especially where accident information is not available" [7].

GISIS-MCI creates a common and standardized platform for casualties and incidents reporting for state parties. It is not aiming to create an accident incident analysis form for shipping companies. Standardized accident/incident and near miss analysis & reporting form should be developed to fulfill ISM requirements. Prompt and effective company analysis for accidents by using this standardized form can enable to exchange found data safely between companies for creating common safety issues. To eliminate reoccurrence of similar accidents, corresponding direct and root causes can be identified, and relevant corrective and preventive actions can be taken. Also, those corrective actions, including root causes and lessons learned shall be circulated among companies.

2.3 Research Gaps

Reviewing relevant literature for both academic and regulatory perspective helped us to find the gaps in the concept of accident/incident analysis. We have not met with research proposing a standardization in accident analysis forms. We used a top-down approach to notify where the gaps are in accident analysis.

At the Top, among various databases, there is MCI module in the GISIS introduced by IMO. A common information flow system was created to record obtained data in the required format. So that further reliable analyses would be made by means of the increased attention towards reporting accidents and identical format of the reports recorded by state parties. It means that there is available and sufficient system for standardization partly on reporting accidents among state parties.

At the second level, there are accident investigation boards to investigate ship accidents having occurred in their territorial waters or the accidents involving the ships carrying their state's flag [27]. There should be a standardized investigation procedure between them to maximize the benefits of a standardized reporting system. However, some countries' maritime authorities design unexpectedly simple reports with no details, while some countries' maritime authorities exert maximum effort in the preparation of accident reports. Hence it cannot be claimed that current accident reporting systems used by maritime authorities are sufficiently detailed. This is the first gap revealed.

At the third level, there are companies which are responsible for investigating accidents occurred in their fleet [7]. In order to reveal whether there is standardization between companies, accident/incident analysis forms used by international shipping companies were examined. It was found that the format and details of accident/incident analysis forms are quite different from each other like accident

investigation boards and do not have a standard structure. This is the second gap noticed, and our focus is especially on this gap in this research.

At the base level, there are ships which are using their companies' forms to investigate accidents/incidents on board. So, if standardization at the company level can be established, there will already be standardization between the merchant fleet.

3. Analysis and Discussion of Results

3.1 Methodology

A network for a working group of eleven maritime companies' representatives operating different type of ships in international waters was established. Priority was given to select companies operating ships in international waters, which were well-known professionals and willing to contribute to the research studies. The percentage of shipping companies operating chemical tanker including ice-class oil tanker is 54.4%, bulk carrier 18.2%, container 18.2% and lastly Ro-Ro ships 9%. Two oceangoing masters from General Directorate of Coastal Safety were also invited to the network. A Member from Turkish Accident Investigation Board joined the group in order to improve our research results.

A sub-working group was established. Ten experts in sum participated in the sub-working group. 50% of participants were seafarers with ship master license, 30% of the participants were seafarers with chief officer license. The remaining share of 20% pertained to academic staff with oceangoing watch-keeping officer ranks. Average maritime employment experience of participants equated to approximately nine years.

The first workshop was held with the working group to discuss how to structure the accident/incident analysis forms. The needs of the maritime sector regarding accident analysis were discussed. During the first workshop, Accident/incident analysis forms of different shipping companies were examined. A presentation was given by Turkish accident investigation board. The needs of accident investigation boards were also emphasized, and suggestions were discussed.

The outputs of the first workshop were examined and outline of the standard accident/incident analysis form was generated. Following, root cause evaluation taxonomy studies were conducted by the project staff.

Following, the second workshop was held. A draft version of the standard accident/incident analysis form was discussed. The semi-structured type was selected as appropriate for analysis & reporting forms. Main headings that will be used to gather information and analyze the occurrence were determined. The system to fulfill the root cause evaluation was also discussed in the workshop.

The outputs of the second workshop were evaluated. The draft forms were revised according to the feedback given in the second workshop. A draft version of root cause evaluation taxonomy was developed. One hundred fifty-two root causes were obtained and put in a list. Seventeen categories were identified, for classification ten experts were led to participate in an interview. The sub-working group was consulted during the taxonomy development step.

Validation studies were conducted for the proposed taxonomy. Randomly selected accident analysis reports were used for the validation study. The evaluation of the root causes found in the five accident reports was reviewed. The root causes stated in these reports were compared to the ones in the proposed taxonomy. From the assessment results, taxonomy demonstrated validity. Following, the final version of the standard form was generated and validated upon applying in maritime accident/incidents. For validation, the expert-judgment validation method was used. The level of the experts' agreement was calculated using the Fleiss Kappa statistic and shown by Kappa value. The result of the validation study showed that the experts had an agreement about the proposed instrument.

After the validation step, a guideline provides guidance on how to fill in the analysis form was prepared. The guideline which consists of sixteen sections was illustrated at the attachment.

The entire process was illustrated in Fig. 5.

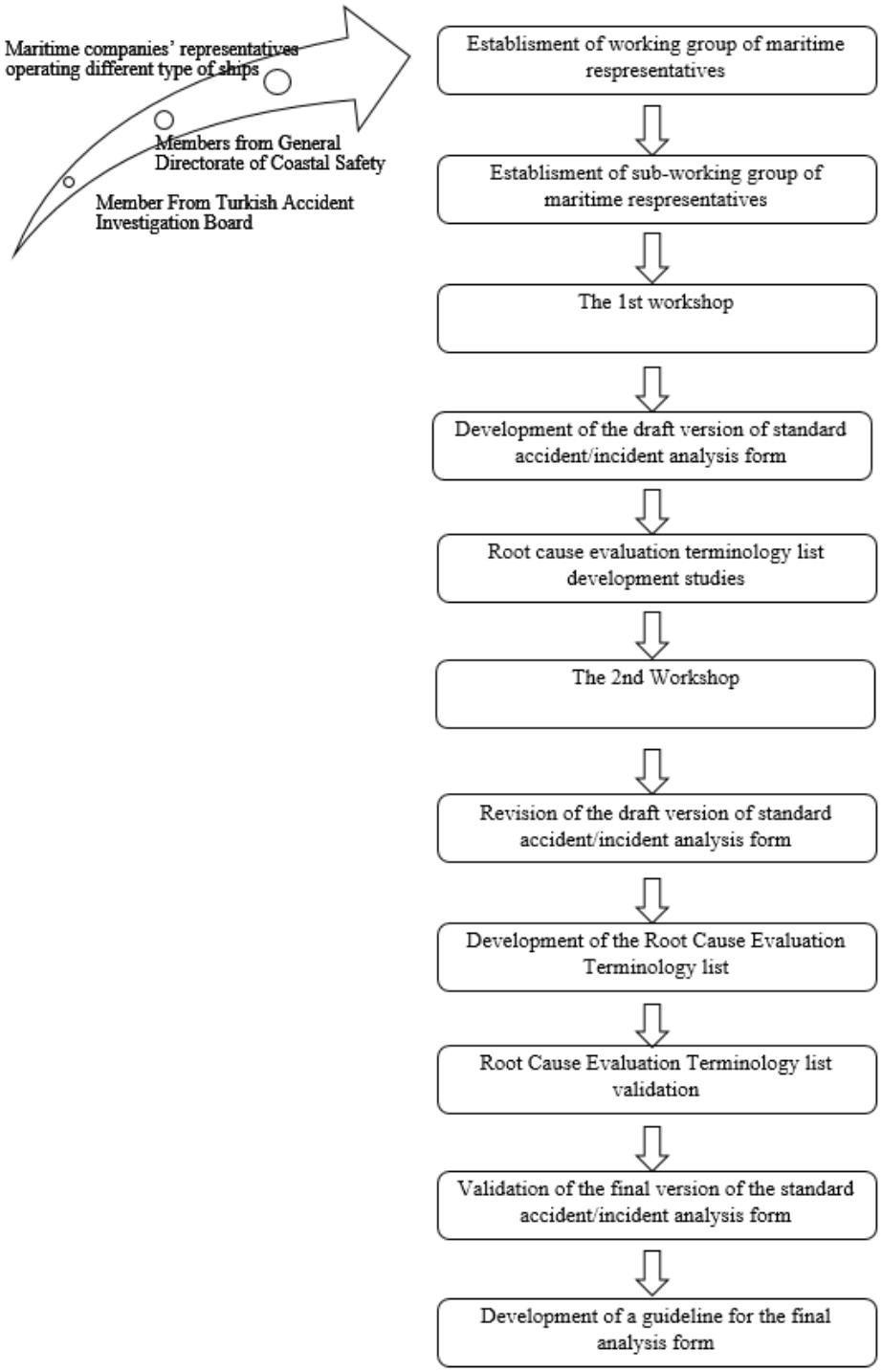

Fig. 5 Standard Accident/Incident or Near-Miss Analysis & Reporting Form Development Steps

3.2 Taxonomy Development

Standardization of root cause taxonomy is a need to facilitate improvements in incident reporting, tracking, and analysis. It is considered that to develop a standard root cause analysis terminology list to be used in the analysis section of the standard form is required to forge a common approach for safety. To serve this purpose, a new up to date taxonomy was developed.

Several methods have been developed to define and classify root causes in the maritime domain. However, a taxonomy accepted as standard is not available, yet. In this project, we applied a method of classification that is based on evaluations of terminology lists with feedback from experts who would use the taxonomy. This approach sought to identify gaps in the terminology and classification to create a multidimensional root cause evaluation taxonomy.

During the taxonomy development stage, a literature review was applied. According to the literature review, Kececi and Arslan [5] studied to utilize a standard technique utilized in accident/incident reporting systems. The paper was extracted from the project coordinator's Ph.D. thesis. In their study, during the process of designing the taxonomy, an analogous approach to the stages of forming a taxonomy entailed by Aviation Security Action Program (ASAP) reporting system which is used in aviation sector was followed. In the data collection process, tanker-companies' Ship Inspection Report Programme (SIRE) and Chemical Distribution Institute (CDI) inspections data were used. Research on MAIB database was conducted. Root causes that were listed in an U.K.-stationed maritime company database were examined. In addition to these resources, ship accident investigation reports released publicly by accident investigation boards of different countries were examined. Commercial software programs and also (ABS) MaRCAT and Det Norske Veritas (DNV) M-SCAT systems were analyzed as a data source. In addition, a literature review was performed. Since, Kececi and Arslan's [5] study includes a wide range of data source, to avoid repetition, the same data sources were not reviewed again in this project, however, the root causes proposed in their study was considered as a resource in itself.

In the next step, recent accident investigation boards reports were reviewed. One hundred recent ship accident investigation reports released publicly by Marine Accident Investigation Branch-U.K., Australian Transport Safety Bureau, Transport Accident Investigation Commission of New Zealand and Accident Investigation Board Norway were examined. The ships listed in the examined reports were in different types and sizes.

In addition to the resources above, eleven shipping companies' accident analysis forms were examined. Root causes included in forms were identified and recorded.

Resources mentioned above were analysed to create a list entailing the root causes. Circa 152 root causes were obtained and put in a list. 17 categories were identified. For classification 10 experts were led to participate in an interview. In addition to determining 17 categories, it was stated that the experts were free to create as many categories as they wished.

10 experts appointed as a sub-working group in sum participated in the interview. The interviews were carried out by the following procedures:

1) A ten-minute presentation was made to the subject of the interview, including the goal of this project and the goal of the taxonomy.
2) Asked the subject to read the list of root causes.
3) Root causes and categories were randomly distributed to avoid impacting the decisions of participants.
4) The subject was asked to classify the root causes in the lists under the categories.
5) During the classification process, the experimenter made an explanation about the questions of the subject one by one.
6) It was measured how many subjects were of the same opinion on the conducted classification.

Based on the feedback from the interview, we organized the draft taxonomy.

For every category and root cause, there's a unique "ID" code to make it easy to cite, 'H' for human factors and 'J' for Job-related factors.

Human-related root causes were grouped under six main headings. These are Human Behaviour, Human Characteristics, Physical/Physiological Capacity-Stress, Psychological capacity- stress, Inadequate Knowledge, Skill, Training, and Factors for Lack of Motivation, respectively.

Human behavior which refers to the way individual acts and interacts is influenced by factors, such as culture, genetic make-up, and individual attitudes and values. 'Culture', 'Character' and 'Lack of self-discipline' were suggested to be under 'Human behavior' category.

Human characteristics is often used to define the factors such as mental reaction time to various stimuli, the capabilities, limitations of short term memory and perception ability. Nine root causes were defined under 'Human characteristics' category. These are 'Low learning aptitude', 'Competence', 'Uncommunicativeness', 'Complacency', 'Slow reaction time', 'Inadequate perception of risk', 'Less than optimal working relationships', 'Vigilance' and 'Inattention'. The root cause 'Inattention' has two sub-factors which are 'Inadequate situational awareness' and 'Attention diverted by non-work related issues'.

Physical factors include physical attributes of the body such as weight and height. Physiological factors term is often used for factors such as strength, visual acuity, tolerance to extremes of temperature and frequency range of human hearing. These two terms were combined as 'Physical/Physiological Capacity-Stress' category. Nine root causes were defined under this category, which are 'Sensory deficiencies', 'Sensitivity', 'Temporary/permanent disabilities', 'Alcohol/drug use', 'Injury or illness', 'Temporary deviation in blood pressure/glucose', 'Seasickness', 'Inappropriate height, weight, size, strength, reach' and 'Fatigue'. 'Sensory deficiencies' has two sub-factors which are 'Vision/hearing deficiency' and 'Other sensory deficiencies (touch, smell, taste, balance)'. 'Sensitivity' also has two sub-factors which are 'Substance sensitivities or allergies' and 'Sensitivities to temperature, sound, etc.'. Lastly, Fatigue has six sub-factors which are 'Fatigue due to task load or duration', 'Fatigue due to lack of rest', 'Fatigue due to sensory overload', 'Fatigue due to extreme concentration/perception demands', 'Routine, monotony, demand for uneventful vigilance' and 'Extreme judgement/decision demands'.

Psychological stress refers to the negative behavioral, emotional and biological response to a perceived threat. Psychological capacity- stress was defined as one of the categories which includes 'Mental/emotional illness', 'Panic', 'Fears and phobias', 'Inappropriate aggression', 'Frustration', 'Pre-occupation with problems', 'Emotional load' and 'Time pressure'.

The fifth category is 'Inadequate Knowledge, Skill, Training' which consists of eleven root causes. These are 'Inadequate practice', 'Insufficient knowledge of the vessel's system/equipment', 'Inadequate technical knowledge', 'Inadequate update training', 'Inadequate initial training', 'Inadequate orientation of the working environment', 'Lack of experience', 'Lack of team training (BRM/BTM)', 'Inadequate knowledge of regulations/standards', 'Inadequate knowledge of ship operations' and 'Poor decision making/information use'.

The last human factors related category is 'Factors for Lack of Motivation'. The root causes defined under this category are 'Lack of incentives', 'Proper performance is punished', 'Improper performance is tolerated', 'Peer pressure among ship crew', 'Improper attempt to gain attention', 'Inadequate performance measurement' and 'Hierarchical pressure'. The sub-factors of 'Inadequate performance measurement' are 'Inadequate performance feedback' and 'Inadequate performance measurement and evaluation'.

Job-related root cause categories were grouped under eleven main headings. These are Communication Problems, Inadequate Leadership, Inadequate Team Culture, Safety-Related Issues, Inadequate Manning Level, Problems Related to System and/or Its Application, Inadequacy in Ship Construction, Design and Equipment, Cargo-Related Issues, Environmental Factors, Third-Party Related Factors, and Commercial Pressure, respectively.

The first category 'Communication Problems' consists of six root causes which are 'Inadequate communication', 'Language difficulties', 'Misunderstanding', 'Speech interference', 'SMCP not used'

and ‘Problem with communication equipment itself’. ‘Inadequate communication’ has four sub-factors defined as ‘Inadequate communication between ships’, ‘Inadequate communication between ship and shore’, ‘Inadequate communication between crew members’ and ‘Inadequate communication between the shipping company and 3rd party’.

The second category ‘Inadequate Leadership’ has eleven root causes which are ‘Unclear or conflicting reporting relationships’, ‘Inadequate initial instructions’, ‘Lack of coaching’, ‘Inadequate review of instruction’, ‘Lack of supervisory/management job knowledge’, ‘Lack of discipline crew/passenger’, ‘Improper or insufficient delegation’, ‘Unclear or conflicting assignment of responsibility’, ‘Improper supervisory example’, ‘Inadequate work planning or programming’ and ‘Insufficient manpower utilized for the task’.

The next category was specified as ‘Inadequate Team Culture’. There are four root causes under this category which are ‘Absence of shared mental model’, ‘Ineffective BRM’, ‘Lack of ownership’ and ‘Over-reliance on people, equipment or system’. ‘Over-reliance on system/equipment’ and ‘Over-reliance on people/supervisor’ are the sub-factors of ‘Over-reliance on people, equipment or system’.

‘Safety Related Issues’ is another root cause category which includes ‘Lack of safety culture’, ‘Unsafe acts’ and ‘Intended actions’. The sub-factors of ‘Unintended actions’ are ‘Mistiming’, ‘Misordering’, ‘Memory failures’ and ‘Overlook’. The two sub-factors of ‘Intended actions’ are ‘Improper attempt to save effort’ and ‘Improper attempt to avoid discomfort’.

‘Inadequate Manning Level’ which is one of the main categories does not have any sub root cause.

‘Problems Related to System and/or Its Application’ category has two root causes which are ‘Procedure, rules and standards’ and ‘Problems related to management’.

‘Problems related to procedure and/or its application’ and ‘Problems related to Rules, standards, regulations and policies’ were defined as sub-factors of ‘Procedure, rules and standards’. ‘Problems related to procedure and/or its application’ has five sub-sub-factors which are ‘Absence of company procedures’, ‘Company procedures does not meet legislative requirements’, ‘Discrepancies between procedures’, ‘Misapplication of procedures’ and ‘Inadequate update of procedures’. ‘Problems related to Rules, standards, regulations and policies’ has six sub-sub-factors which are ‘Absence of rules, regulations, policies, standards’, ‘Misapplication of rules, regulations, policies, standards’, ‘Poor/ambiguous rules, regulations, policies, standards’, ‘Increasing international rules’, ‘Absence of classification society rules/guidelines’ and ‘Problems related to working standards’. ‘Problems related to working standards’ has its own sub-factors which are defined as ‘Inadequate development of working standards’, ‘Inadequate communication of working standards’, ‘Inadequate maintenance of working standards’ and ‘Inadequate monitoring of compliance of work standards.

‘Problems related to management’ has two sub-factors determined as ‘Inadequate company system management’ and ‘Inadequate risk assessment’. There are seven sub-sub-factors of ‘Inadequate company system management’ which are ‘Lack of corrective actions taken’, ‘Inadequate company standing orders’, ‘Inadequacy in keeping/preserving documents orderly’, ‘Certification fraud’, ‘Inadequate inspection’, ‘Inadequate warning system’ and ‘Providing inadequate reference documents, directives and guidance publications’. Likewise, ‘Inadequate risk assessment’ has three sub-sub - factors which are ‘Risk assessment process is inadequate’, ‘Risk assessment process not implemented’ and ‘Taking ineffective risk related precautions’.

‘Inadequacy in Ship Construction, Design and Equipment’ is another job related main category. There are six root causes stated under this category which are ‘Inadequacy in ship construction and design’, ‘Material/mechanical failure’, ‘Inadequate material/equipment’, ‘Inadequate maintenance’, ‘Problem with ship handling characteristics’ and ‘Inadequate purchasing’. Seven sub root causes identified under ‘Inadequacy in ship construction and design’ are ‘Inadequate consideration of human factors/ergonomics’, ‘Inadequate monitoring & evaluation of changes’, ‘Inadequate assessment of operational readiness’, ‘Assembly defect in construction’, ‘Construction defect’, ‘Design inadequate’ and ‘Construction material select defect’. Ten sub root causes specified under ‘Material/mechanical failure’ are ‘Brittle fracture of equipment’, ‘Cavitation damage’, ‘Corrosion’, ‘Casting defect’, ‘Gross plastic deformation’, ‘Seal/gasket defect’, ‘Material fatigue’, ‘Worn out of equipment’, ‘Weld defect’

and ‘U.V. /Chemical deterioration’. Nine sub-factors identified under ‘Inadequate material/equipment’ are ‘Equipment poorly designed’, ‘Equipment not operational’, ‘Computer based systems are not logic’, ‘Equipment/tool/material misuse’, ‘Inadequate removal and replacement of unsuitable tools/equipment’, ‘Inadequate availability of tools/equipment’, ‘Inadequate standards and specifications of tools/equipment’, ‘Equipment/ Material select defect’ and ‘Equipment used by unauthorized person’. Six sub root causes stated under ‘Inadequate maintenance’ are ‘Inadequate preventive assessment of maintenance needs’, ‘Inadequate reparative communication of maintenance needs’, ‘Inadequate adjustment/repair/maintenance of tools/equipment’, ‘Inappropriate temporary repairs’, ‘Inadequate inspection/monitoring of equipment’ and ‘Inadequate salvage and reclamation of tools/equipment’. ‘Inadequate purchasing’ also has seven sub root causes specified as ‘Inadequate contractor selection’, ‘Inadequate specifications on requisitions’, ‘Inadequate research on material/equipment’, ‘Inadequate mode or route of shipment’, ‘Inadequate communication of safety and health data’, ‘Improper handling of materials’ and ‘Improper storage of materials’.
‘Cargo Related Issues’ category has four root causes which are ‘Cargo deterioration’, ‘Cargo self-ignition’, ‘Cargo interaction’ and ‘Radiation’.
‘Environmental Factors’ main category has three root causes which are ‘Natural environment’, ‘External environment’ and ‘Working environment’. ‘Natural environment’ has ten sub-factors determined as ‘Current’, ‘Heavy weather’, ‘Tide’, ‘Abnormal waves’, ‘Natural disasters’, ‘Hazardous natural environment’, ‘Ice’, ‘Temperature extremes’, ‘Humidity’ and ‘Visual environment/lightning’. ‘External environment’ has seven sub-factors which are ‘Own vessel's rope/net’, ‘Other vessel's rope/net’, ‘Flying objects’, ‘Floating objects’, ‘Other vessels’, ‘Uncharted underwater obstruction’ and ‘Intense vessel traffic’. ‘Working environment’ has six sub-factors specified as ‘Noise’, ‘Vibration’, ‘Poor housekeeping’, ‘Unclean working place (tank etc.)’, ‘Poor or excessive lightening of working place’ and ‘Inadequate ventilation’.
‘Third Party Related Factors’ main category has six root causes which were stated as ‘Manufacturer did not provide sufficient guidance’, ‘Inadequate navigational information provided/demand’, ‘Tug related deficiencies’, ‘Pilotage related deficiencies’, ‘Inadequate Flag state/ port state inspection’ and ‘Custom procedure deficiencies’. ‘VTS not provided/requested information’ and ‘Appropriate information not provided by/requested from the regional authority’ are the two sub-factors of ‘Inadequate navigational information provided/demand’.
The last category ‘Commercial Pressure’ does not have a sub-factor.

3.3. Taxonomy validation study

In order to validate the structured draft taxonomy, randomly selected accident reports were used. All accident reports were selected from different countries’ maritime accident investigation branch. Five different countries' accident investigation reports were examined. These countries and marine accident investigation branches are as follows.

- The United Kingdom, Marine Accident Investigation Branch
- Australia, Australian Transport Safety Bureau
- New Zealand, Transport Accident Investigation Commission
- Norway, Accident Investigation Board Norway
- Malta, Marine Safety Investigation Unit

The involved ship types were product tanker, container vessel, bulk carrier, passenger vessel, and general cargo vessel. Attention was paid to select recent reports. Two of the accidents belonged to the year 2018, two accidents belonged to the year 2017 and one accident belonged to the year 2015. The date in which accidents took place and the date in which the investigation ended were different.
The above-mentioned accident reports were randomly selected. The root causes stated in each accident report were examined with the draft proposed taxonomy, and it is tried to determine the accuracy percentage of the taxonomy.

In the first report which belongs to MAIB, a ship accident that resulted in the death of a person was examined. The type of ship involved in the accident was General Cargo and the year of the accident was 2018.
The number of the findings described in the conclusion of the report was eleven which are given in Table 2 in the left column. In the right column of Table 2, the corresponding root causes in the proposed taxonomy for each finding are presented.

Table 2. Comparison results of the first report

Findings	**Corresponding Root Causes In Proposed Taxonomy**
Inadequate procedures	J 12.1.1.1. Absence of company procedures
Sense of urgency	J 10.2.2.1. Time pressure
Effects of alcohol	H 3.4. Alcohol/drug use
Not realize the risk	H 2.6. Inadequate perception of risk
The operation was not being adequately supervised	J 8.2. Inadequate initial instructions J 8.3. Lack of coaching
Focus on an operation distract sb from his/her supervisory role	3.9.6. Extreme judgment/decision demands
SMS was immature	12.1.1.1. Absence of company procedures 12.1.1.5. Inadequate update of procedures
Risk assessments had not been conducted for some operations	J 12.2.2. Inadequate risk assessment J12.2.2.2. Risk assessment process not implemented
A safe system of work for some operations had not been developed	J 12.1.1.1. Absence of company procedures
Maintenance routines were not in place	13.4. Inadequate maintenance
Weak safety culture	10.1. Lack of safety culture

As a result, the findings in the first report were met by our taxonomy in 11/11 ratio. This value alone is not sufficient to demonstrate validity. Therefore, the assessment of the total number of findings indicated in the five accident reports was evaluated.
In the second report which belongs to ATSB, container accident case was investigated. The accident belonged to the year 2018. The findings stated in the accident investigation report is presented in Table 3.

Table 3. Comparison results of the second report

Findings	Corresponding Root Causes in proposed taxonomy
Placed the ship in risk	2.6. Inadequate perception of risk
The action was inconsistent with the master's standing orders, company procedures, and the İnternational Regulations	12.1.1.4. Misapplication of procedures 12.1.2.2. Misapplication of rules, regulations, policies, standards
The action was not made in sufficient time	10.2.1.1. Mistiming
contravention of company procedures and international regulations	10.1. Lack of safety culture*
The action was not substantial	5.11. Poor decision making/information use

In the second report, the findings were met by our taxonomy in 5/5 ratio.
In the third report which belongs to New Zealand, a passenger vessel accident case was analyzed. The accident belonged to the year 2017.
The findings described in the conclusion of the report is given in Table 4.

Table 4. Comparison results of the third report

Findings	Corresponding Root Causes in proposed taxonomy
Lost situational awareness	2.9.1. Inadequate situational awareness
Not speak up until it was too late	7.1. Inadequate communication
There was no discussion by the bridge team	9. Inadequate Team Culture 5.8. Lack of team training (BRM/BTM)
The indicator was faulty	13.3.2. Equipment not operational
The crew were not totally familiar with and did not use all of the safety features of the ECDIS	5.2. Insufficient knowledge of the vessel's system/equipment
The darkness and absence of visual navigation aids	15.1.10.Visual environment/lightning
The bridge team were totally reliant on the ship’s electronic navigation aids and systems	9.4.1. Over-reliance on system/equipment
The regional authority had not taken sufficient measures to reduce the risk of large ships	16.2.2. Appropriate information not provided by/requested from the regional authority
bridge resource management	9.2. Ineffective BRM 5.8. Lack of team training (BRM/BTM)

In the third report, the findings were met by our taxonomy in 9/9 ratio.
In the fourth report which belongs to Norway, a product tanker ship accident case was examined. The accident which belonged to the year 2015 resulted in death.
The findings described in the report is given in Table 5.

Table 5. Comparison results of the fourth report

Findings	Corresponding Root Causes in proposed taxonomy
Not conducted a risk assessment prior to commencing the work.	12.2.2.2. Risk assessment process not implemented
The rubber feet were significantly worn	13.2.8. Worn out of equipment

In the fourth report, two findings were indicated and all of them were met by the draft taxonomy. As a result, the findings in the fourth report were met by our taxonomy in 2/2 ratio.
In the fifth report which belongs to Malta, a bulk carrier accident case was analyzed. The accident which resulted in serious injury to crew member belonged to 2017.
The findings described in the report is given in Table 6.

Table 6. Comparison results of the fifth report

Findings	Corresponding Root Causes in proposed taxonomy
Communication between the crew and the tug boat was not adequate	7.1.1. Inadequate communication between ships
Hazards was not followed up by on-site risk assessment	12.2.2.2.Risk assessment process not implemented
Earlier successful operations may have been influential	9.4. Over-reliance on people/supervisor
The risk of injury was overlooked or not spotted by the C/O	10.2.1.4. Overlook 8.3. Lack of coaching

In the fifth report, four findings were indicated and the draft taxonomy met all of them. As a result, the findings in the fifth report were met by our taxonomy in 4/4 ratio.
The evaluation of the root causes found in the five accident reports was reviewed. The number of root causes stated in the five accident reports was thirty-one in total. The proposed taxonomy met all the root causes. As a result, it can be said that the taxonomy generated constitutes 100% validity for the root causes of randomly selected accident reports as it covers the root causes of the accident reports at the rate of 31/31.
From the assessment results, taxonomy demonstrates validity, ease of use, as well as good application value to identifying root causes of maritime accidents. Therefore, we find that the taxonomy is appropriate to assist maritime professionals to perform root cause analysis of maritime accidents.
The taxonomy obtained after the validation study is shown in Table 7 and Table 8.
Human-related root causes listed in Table 7 were grouped under six main headings. These are Human Behaviour, Human Characteristics, Physical/Physiological Capacity-Stress, and Psychological capacity- stress, Inadequate Knowledge, Skill, Training and Factors for Lack of Motivation, respectively. For Human Factors category, there's a unique "ID" code which starts with 'H' to make it easy to cite, shown in the left column.

Table 7. Human related root cause evaluation taxonomy

HUMAN RELATED FACTORS
H1. Human Behaviour
1.1. Culture
1.2. Character
1.3. Lack of self-discipline
H2. Human Characteristics
2.1. Low learning aptitude
2.2. Competence
2.3. Uncommunicativeness
2.4. Complacency
2.5. Slow reaction time
2.6. Inadequate perception of risk
2.7. Less than optimal working relationships
2.8. Vigilance
2.9. Inattention
2.9.1. Inadequate situational awareness
2.9.2. Attention diverted by non-work related issues
H3. Physical/Physiological Capacity-Stress
3.1. Sensory deficiencies
3.1.1. Vision/hearing deficiency
3.1.2. Other sensory deficiencies (touch, smell, taste, balance)
3.2. Sensitivity
3.2.1. Substance sensitivities or allergies
3.2.2. Sensitivities to temperature, sound, etc.
3.3. Temporary/permanent disabilities
3.4. Alcohol/drug use
3.5. Injury or illness
3.6. Temporary deviation in blood pressure/glucose
3.7. Seasickness
3.8. Inappropriate height, weight, size, strength, reach, etc.
3.9. Fatigue
3.9.1. Fatigue due to task load or duration
3.9.2. Fatigue due to lack of rest
3.9.3. Fatigue due to sensory overload
3.9.4. Fatigue due to extreme concentration/perception demands
3.9.5. Routine, monotony, demand for uneventful vigilance
3.9.6. Extreme judgment/decision demands
H4. Psychological capacity- stress
4.1. Mental/emotional illness
4.2. Panic
4.3. Fears and phobias
4.4. Inappropriate aggression
4.5. Frustration
4.6. Pre-occupation with problems
4.7. Emotional load
4.8. Time pressure

H5. Inadequate Knowledge, Skill, Training

- 5.1. Inadequate practice
- 5.2. Insufficient knowledge of the vessel's system/equipment
- 5.3. Inadequate technical knowledge
- 5.4. Inadequate update training
- 5.5. Inadequate initial training
- 5.6. Inadequate orientation of the working environment
- 5.7. Lack of experience
- 5.8. Lack of team training (BRM/BTM)
- 5.9. Inadequate knowledge of regulations/standards
- 5.10. Inadequate knowledge of ship operations
- 5.11. Poor decision making/information use

H6. Factors for Lack of Motivation

- 6.1. Lack of incentives
- 6.2. Proper performance is punished
- 6.3. Improper performance is tolerated
- 6.4. Peer pressure among ship crew
- 6.5. Improper attempt to gain attention
- 6.6. Inadequate performance measurement
  - 6.6.1. Inadequate performance feedback
  - 6.6.2. Inadequate performance measurement and evaluation
- 6.7. Hierarchical pressure

Job-related root causes listed in Table 8 were grouped under eleven main headings. These are Communication Problems, Inadequate Leadership, Inadequate Team Culture, Safety-Related Issues, Inadequate Manning Level, Problems Related to System and/or Its Application, Inadequacy in Ship Construction, Design and Equipment, Cargo-Related Issues, Environmental Factors, Third-Party Related Factors, and Commercial Pressure, respectively. For these job-related category, there's a unique "ID" code which starts with 'J' to make it easy to cite.

Table 8. Job related root cause evaluation taxonomy

JOB RELATED FACTORS
J7. Communication Problems
7.1. Inadequate communication
7.1.1. Inadequate communication between ships
7.1.2. Inadequate communication between ship and shore
7.1.3. Inadequate communication between crew members
7.1.4. Inadequate communication between shipping company and 3rd party
7.2. Language difficulties
7.3. Misunderstanding
7.4. Speech interference
7.5. SMCP not used
7.6. Problem with communication equipment itself
J8. Inadequate Leadership
8.1. Unclear or conflicting reporting relationships
8.2. Inadequate initial instructions
8.3. Lack of coaching
8.4. Inadequate review of instruction
8.5. Lack of supervisory/management job knowledge
8.6. Lack of discipline crew/passenger
8.7. Improper or insufficient delegation
8.8. Unclear or conflicting assignment of responsibility
8.9. Improper supervisory example
8.10. Inadequate work planning or programming
8.11. Insufficient manpower utilized for the task
J9. Inadequate Team Culture
9.1. Absence of shared mental model
9.2. Ineffective BRM
9.3. Lack of ownership
9.4. Over-reliance on people, equipment or system
9.4.1. Over-reliance on system/equipment
9.4.2. Over- reliance on people/supervisor
J10. Safety Related Issues
10.1. Lack of safety culture
10.2. Unsafe acts
10.2.1. Unintended actions
10.2.1.1. Mistiming
10.2.1.2. Misordering
10.2.1.3. Memory failures
10.2.1.4. Overlook
10.2.2. Intended actions
10.2.2.1. Improper attempt to save effort
10.2.2.2. Improper attempt to avoid discomfort
10.3. Sabotage
J11. Inadequate Manning Level

J12. Problems Related to System and/or Its Application

12.1. Procedure, rules and standards

12.1.1. Problems related to procedure and/or its application

12.1.1.1. Absence of company procedures

12.1.1.2. Company procedures does not meet legislative requirements

12.1.1.3. Discrepancies between procedures

12.1.1.4. Misapplication of procedures

12.1.1.5. Inadequate update of procedures

12.1.2. Problems related to Rules, standards, regulations and policies

12.1.2.1. Absence of rules, regulations, policies, standards

12.1.2.2. Misapplication of rules, regulations, policies, standards

12.1.2.3. Poor/ambiguous rules, regulations, policies, standards

12.1.2.4. Increasing international rules

12.1.2.5. Absence of classification society rules/guidelines

12.1.2.6. Problems related to working standards

12.1.2.6.1. Inadequate development of working standards

12.1.2.6.2. Inadequate communication of working standards

12.1.2.6.3. Inadequate maintenance of working standards

12.1.2.6.4. Inadequate monitoring of compliance of work standards

12.2. Problems related to management

12.2.1. Inadequate company system management

12.2.1.1. Lack of corrective actions taken

12.2.1.2. Inadequate company standing orders

12.2.1.3. Inadequacy in keeping/preserving documents orderly

12.2.1.4. Certification fraud

12.2.1.5. Inadequate inspection

12.2.1.6. Inadequate warning system

12.2.1.7. Providing inadequate reference documents, directives and guidance publications

12.2.2. Inadequate risk assessment

12.2.2.1. Risk assessment process is inadequate

12.2.2.2. Risk assessment process not implemented

12.2.2.3. Taking ineffective risk related precautions

J13. Inadequacy in Ship Construction, Design and Equipment

13.1. Inadequacy in ship construction and design

13.1.1. Inadequate consideration of human factors/ergonomics

13.1.2. Inadequate monitoring & evaluation of changes

13.1.3. Inadequate assessment of operational readiness

13.1.4. Assembly defect in construction

13.1.5. Construction defect

13.1.6. Design inadequate

13.1.7. Construction material select defect

13.2. Material/mechanical failure

13.2.1. Brittle fracture of equipment

13.2.2. Cavitation damage

13.2.3. Corrosion

13.2.4. Casting defect

13.2.5. Gross plastic deformation

13.2.6. Seal/gasket defect

13.2.7. Material fatigue

13.2.8. Worn out of equipment
13.2.9. Weld defect
13.2.10. U.V. /Chemical deterioration

13.3. Inadequate material/equipment
13.3.1. Equipment poorly designed
13.3.2. Equipment not operational
13.3.3. Computer based systems are not logic
13.3.4. Equipment/tool/material misuse
13.3.5. Inadequate removal and replacement of unsuitable tools/equipment
13.3.6. Inadequate availability of tools/equipment
13.3.7. Inadequate standards and specifications of tools/equipment
13.3.8. Equipment/ Material select defect
13.3.9. Equipment used by unauthorized person

13.4. Inadequate maintenance
13.4.1. Inadequate preventive assessment of maintenance needs
13.4.2. Inadequate reparative communication of maintenance needs
13.4.3. Inadequate adjustment/repair/maintenance of tools/equipment
13.4.4. Inappropriate temporary repairs
13.4.5. Inadequate inspection/monitoring of equipment
13.4.6. Inadequate salvage and reclamation of tools/equipment

13.5. Problem with ship handling characteristics

13.6. Inadequate purchasing
13.6.1. Inadequate contractor selection
13.6.2. Inadequate specifications on requisitions
13.6.3. Inadequate research on material/equipment
13.6.4. Inadequate mode or route of shipment
13.6.5. Inadequate communication of safety and health data
13.6.6. Improper handling of materials
13.6.7. Improper storage of materials

J14. Cargo Related Issues

14.1. Cargo deterioration
14.2. Cargo self-ignition
14.3. Cargo interaction
14.4. Radiation

J15. Environmental Factors

15.1. Natural environment
15.1.1. Current
15.1.2. Heavy weather
15.1.3 Tide
15.1.4. Abnormal waves
15.1.5. Natural disasters
15.1.6. Hazardous natural environment
15.1.7. Ice
15.1.8. Temperature extremes
15.1.9. Humidity
15.1.10. Visual environment/lightning

15.2. External environment
15.2.1. Own vessel's rope/net
15.2.2. Other vessel's rope/net
15.2.3. Flying objects
15.2.4. Floating objects

15.2.5. Other vessels
15.2.6. Uncharted underwater obstruction
15.2.7. Intense vessel traffic

15.3. Working environment
15.3.1. Noise
15.3.2. Vibration
15.3.3. Poor housekeeping
15.3.4. Unclean working place (tank etc.)
15.3.5. Poor or excessive lightening of working place
15.3.6. Inadequate ventilation

J16. Third Party Related Factors

16.1. Manufacturer did not provide sufficient guidance
16.2. Inadequate navigational information provided/demand
16.2.1. VTS not provided/requested information
16.2.2. Appropriate information not provided by/requested from the regional authority
16.3. Tug related deficiencies
16.4. Pilotage related deficiencies
16.5. Inadequate Flag state/ port state inspection
16.6. Custom procedure deficiencies

J17. Commercial Pressure

3.4. Accident/Incident and Near-miss Analysis & ReportingForms

3.4.1. Type selection

During the workshops we held, expert opinion was consulted to determine the best structure model. There are three different form of design. Some companies prefer to use unstructured design which means open-ended questions, whereas some companies prefer to use structured one which consists of closed-ended questions. And few of them uses the semi-structured version which includes both open and closed-ended questions. Table 9 shows the advantages and disadvantages of the structure types.

Table 9. Comparison of form structures

Type of Form	Advantages	Disadvantages
Unstructured (Open-Ended)	Provides highly detailed and valid data. Extremely flexible. Natural and unrestricted, it can reveal more about the accident.	Not standardized so cannot replicate. Problem with reliability and generalizing. Difficult to quantify and analyze accident. Difficult to compare accidents. Time-consuming.
Structured (Closed-Ended)	Easy to quantify and analyze the accident. Reliable. Can be replicated. Time-efficient (Fast to complete). Large amounts of detail generated.	Less valid due to distortion of restricted answers and closed questions. Cause and effect may not be inferred.
Semi-Structured	A large amount of detail generated. Fairly flexible and sensitive. Fairly reliable and easy to analyze. Cause and effect can be inferred. Optimized between time and data.	The flexibility of analysis may lessen reliability. Open-ended questions are difficult to analyze.

During the workshop discussions, it was found that reliability and ease to analyses were the important points to be taken into consideration in type selection. Also, it is noted that the cause and effect relationship should be clarified. Semi-structured type has these characteristics and its disadvantages can be accepted as reasonable handicaps. Therefore, semi-structured type was selected as appropriate for analysis forms.

3.4.2. Form design

During the workshop discussions, experts were asked what features an accident analysis form should have. According to the suggestions of experts, an accident analysis form structure must have below characteristics.

- Easy to understand
- Not have a complex structure, easy to fill
- Have a section for maritime accident-specific root cause evaluation
- To be used for both accident/incident case and near-miss case
- To be used for both analysis and reporting
- Should be in a form that is partially selective but mostly has sections for writing.
- Include all relevant information for analysis

The relevant information that was suggested to be included in the analysis form is as follows.

1. Vessel name
2. Case number
3. Analysis start date
4. Analysis completed date
5. Type of occurrence
   (It should be noted in the analysis form whether the occurrence was an accident, an incident or a near-miss.)
6. Type of loss
   (This section should include people, environment, property and process/operation/business)
7. Loss severity
   Severity of Consequence Level Descriptions; Catastrophic, Critical, Marginal and Negligible
8. Loss description
9. Consequence of harm to person (if there is)
   (Consequences such as first aid case, lost workday case, permanent partial disability, permanent total disability, medical treatment case, restricted work case, fatality)
10. Comments on harm to person (if there is)
11. Description of event
    A statement of sequence of events that preceded the incident
12. The date of occurrence
13. Time of occurrence
14. Location of the occurrence
15. Weather condition
16. Person involved in occurrence
    The name and job titles of anyone injured or killed in the accident/incident
17. Geographical area
18. Ship position
19. Loading condition of the ship
20. Photographs related to the occurrence
21. Corrective action(s)
22. Preventive action(s)
23. The names and job titles of witnesses
24. Identification of root causes that significantly contributed to the accident/incident
25. The corrective actions determined to prevent the recurrence of similar accidents
26. Preventive actions
27. Attachment
28. The names and job titles of the individuals who carried out or participated in the analysis process
29. Company remark(s)

The structure of the accident analysis & reporting form was created by reviewing the necessary information mentioned above.

3.4.3. Validation

According to the feedback given in workshops, an accident/incident & near miss analysis& reporting form was generated. For validation, the expert-judgment validation method was used. In order to finalize the developed form, the Delphi method was used. Three experts participated in this process by giving their opinion and suggestions based on their experiences and knowledge. The level of the experts' agreement was calculated using the Fleiss Kappa statistic and shown by Kappa value.
The expert judgment is a method to define the quality of the proposed instrument [32]. There are various expert judgment methods that can be applied, such as the Delphi method, interview,

questionnaire, etc. [32], [33]. The Delphi method is an iterative process that may conduct until several rounds or until the agreement criteria are met [32]–[34].
The three experts were selected based on their experience in the field. All experts were seafarers with ship master license and they were working in the Health and Safety Department in a shipping company.
A questionnaire with five questions was developed and by using the Delphi method, the maritime experts were asked to provide their opinion. The questionnaire is given in Table 10.

Table 10. Questionnaire for validation study

No.	Question
Q1	Easy to understand
Q2	Not have a complex structure, easy to fill
Q3	Include all relevant information for analysis
Q4	Allows root cause analysis
Q5	Have a structure that is partially selective but mostly has sections for writing

In the questionnaire, the maritime experts answered each question by giving three scale rating which shows the level of acceptance. Rating of 1 indicates that the expert disagreed, a rating of 2 means that the experts were neutral, and a rating of 3 shows that the experts agreed. The experts were also asked to comment on the form if they have any suggestions.

In the analysis phase, the level of agreement between experts was measured. To validate the agreement between experts, the interrater reliability was measured by using the Fleiss kappa statistic [32], [35]. Fleiss kappa is the extended version of the Cohen kappa statistic, which can be used to measure the level of agreement of several raters in several categories. The agreement level was determined by Kappa value (K) and calculated by the following formula:

$$K = (Pr(a) - Pr(e))/(1 - Pr(e)) \quad (1)$$

where Pr(a) is the difference between the level of agreement and Pr(e) is the agreement by chance. Kappa value is differing from the value of '-1' and '1'. The negative value of Kappa shows the disagreement and the positive value shows agreement. There is a different interpretation for each range. A common interpretation which divides Kappa value into six ranges as shown in Table 11 was defined by [36].

Table 11. Interpretation of Kappa value

Range of Value	Interpretation
$K \leq 0$	No agreement
$0.01 \leq K \leq 0.20$	Slight agreement
$0.21 \leq K \leq 0.40$	Fair agreement
$0.41 \leq K \leq 0.60$	Moderate agreement
$0.61 \leq K \leq 0.80$	Substantial agreement
$0.81 \leq K \leq 1.00$	Almost perfect agreement

Moreover, according to Brennan and Prediger [37], the Kappa value of 0.7 shows that the level of agreement is reliable. In this validation study, we accepted that if the Kappa value has reached 0.7, the current Delphi round is fulfilled the substantial agreement and there is a satisfactory agreement between the maritime experts. This means that the Delphi method has ended and there is no need for an additional round.

For calculation of Kappa value, the number of the measured items was five (N=5), the number of raters was three (n=3), and the number of ratings was three (k=3). The rating results were given in Table 12.

Table 12. Number of ratings

Result	Amount
the same rating was given by all experts	5
the same rating was given by two experts	0
the different rating was given by each expert	0

All the experts gave the same rating value to the questionnaire, which means that we found Pr(a) value is 1 and Pr(e) value is 0. Based on the Pr(a) and Pr(e) values, the Kappa value was found to be 1 which means that all experts were agreed with the proposed structure.
The result of the validation study showed that the experts had an agreement about the proposed instrument.

To finalize the validation studies, five accidents which belonged to different shipping companies were examined by three experts. The details of accident analyzes cannot be shared in this document due to the confidentiality of company information. The experts confirmed that the proposed form contains all the necessary sections and information to analyze the given accidents. The final structure of the form is illustrated in Fig. 6.

LOGO & SHIPPING COMPANY NAME	Form No Issue Date Revision No Revision Date Issued by Approved by

ACCIDENT/INCIDENT OR NEAR MISS ANALYSIS& REPORTING FORM

Vessel:	Case No:	Analysis commence date: Analysis completed date:

Accident ☐ Incident ☐ Near miss ☐

Type of Loss

Person	☐	Property/Asset	☐
Environment	☐	Process/operation/business	☐

Loss Severity

Catastrophic	☐	Critical	☐	Marginal	☐
Minor	☐	Negligible	☐		

Description of loss (if there is)

Details of Injured Person

Name		Rank		D.O.B.		Sex		Nationality	
Other:									

Type of harm to person (if there is)

First Aid Case	☐	Permanent Partial Disability	☐	Restricted Work Case	☐
Lost Workday Case	☐	Permanent Total Disability	☐	Fatality	☐
Other	☐	Medical Treatment Case	☐		

Comments:

Conditions & Additional Details

Date & Time of occurence				Ship position (Lat-Long)			
Ship operation area				Geographical area			
Loading condition				Specific location of occurence on board			
Weather		Wind		Current		Visibility	
Sea state		Wave					
Other:							

Description of Event

Additional sheets attached ☐	Photographs attached ☐

Witness(es) Name & Rank:

Fig.6. Analysis & reporting form structure

ROOT CAUSE ANALYSIS

Corrective Actions

Preventive Actions

Lessons Learnt

Person/(s) who carried out analysis with Master Name & Rank	MASTER Name Signature

FOR OFFICE USE

Date received	Further Action Required?	Date closed
	Y ☐ N ☐	
Company remarks: Name: Signature:		

Fig.6. Analysis & reporting form structure (cont.)

3.5. Development of a guideline for use of analysis & reporting form

In the last step of project studies, a guideline containing information regarding the standard analysis & reporting form was generated. It will provide guidance on how to fill in the analysis & reporting form. The guideline consists of sixteen sections.

- In the first section, case specific information such as vessel name, case number, analysis commence date and analysis completed date were explained.
- In the second section, the meaning of accident, incident and near miss were explained in detail. Since the necessity of disclosure is stated in the workshops, these explanations were added in the guidance.
- In the third section, loss and type of loss were mentioned.
- In the fourth section, loss severity terms were explained.
- In the fifth section, the description of loss section was referred.
- In the sixth section, details of the injured person were mentioned.
- In the seventh section is about the type of harm to a person. In this part, first aid case, permanent partial disability, restricted work case, lost workday case, permanent total disability, fatality, and medical treatment case were explained.
- In the eighth section, conditions and additional details were stated.
- In the ninth section, a description of the event was mentioned.
- In the tenth section, information about the witness(es) was given.
- In the eleventh section, given information regarding root cause evaluation taxonomy.
- In the twelfth section, the meaning of corrective action was explained.
- In the thirteenth section, the meaning of preventive action was stated.
- In the fourteenth section, lessons learned was remarked.
- In the fifteenth section was about the information regarding the people who carried out the analysis with Master.
- In the sixteenth section, Office use section in which company remarks will be given was explained.

The developed guideline is given in section 3.5.1.

3.5.1. Reference guideline for use of accident/incident or near-miss analysis & reporting form

REFERENCE GUIDELINE FOR USE OF ACCIDENT/INCIDENT OR NEAR-MISS ANALYSIS & REPORTING FORM

When an incident/accident or near miss occurs, you must immediately analyze the occurrence to identify unsafe acts, conditions or procedures, as far as possible, to ensure that work can be done safely. The information about the use of the analysis & reporting form to be completed is given below.

I. Occurrence descriptive information takes place on the top of the analysis & reporting form.

Vessel: Vessel name must be indicated on the form.
Case no: Use the space to assign a unique case number to each individual accident.
Analysis commences date: Use the space to indicate the date on which the analysis started. Do not confuse with the date of occurrence or the date on which the analysis completed.
Analysis completed date: Use the space to indicate the date on which the analysis completed.

II. Use the checkbox to select the type of occurrence.

Accident: Occurrence which has inadvertently caused a loss or hazard to life, property, and environment, is called an accident.
An accident does not include a deliberate act or omission, with the intention to cause harm to an individual, the environment or the safety of a ship.

Incident: According to Res. MSC.255(84), a marine incident means an event, or sequence of events, other than a marine casualty, which has occurred directly in connection with the operations of a vessel that endangered, or, if not corrected, would endanger the safety of the ship, its occupants or any other person or the environment.
A marine incident does not include a deliberate act or omission, with the intention to cause harm to an individual, the environment or the safety of a ship.

Near Miss: As stated in MSC-MEPC.7/Circ.7 a near-miss means a sequence of events and/or conditions that could have resulted in a loss. This loss was prevented only by a fortuitous break in the chain of events and/or conditions. The potential loss could be an injury, environmental damage, or negative business impact (e.g., repair or replacement costs, contract violations, loss of reputation, scheduling delays).
Some examples of a near-miss given in (MSC-MEPC.7/Circ.7) help to illustrate this definition:

- Any occurrence that leads to the implementation of an emergency procedure, plan or response and thus prevents a loss. For instance, a collision is narrowly avoided; or a crew member double checks a valve and discovers a wrong pressure reading on the supply side.
- Any occurrence where an unexpected condition could lead to an adverse consequence, but which does not occur. For instance, a person moves from a location immediately before a crane unexpectedly drops a load of cargo there; or a ship finds itself off-course in normally shallow waters but does not ground because of an unusual high-spring tide.

- Any dangerous situation or condition that is not discovered until after the danger has passed. For instance, a vessel safely departs a port of call and discovers several hours into the voyage that the ships radio was not tuned to the Harbour Masters radiofrequency; or it is discovered that ECDIS displays scale does not match the scale, projection, or orientation of the chart and radar images.

III. TYPE OF LOSS

Use the checkbox to select the type of loss.

The loss means any hazard to human life, property or environment is called a Loss. Obvious losses are mostly those of life, environment, and property, however, a loss may also be not obvious, which are, for instance;

- Loss of reputation
- Interruption or suspension of an operation
- Scheduling delays
- Time loss, and
- Consequences of all above

Losses may be incurred immediately after an incident or further after a certain period.

IV. LOSS SEVERITY

Use the checkbox to select the loss severity.

Catastrophic: Multiple fatalities, total loss of the ship, or extreme environmental impact

Critical: Single-fatality, disabling injury or illness, major vessel damage, major environmental impact, or business downtime.

Marginal: Multiple or severe Injuries requiring more than first aid, local vessel damage, some environmental damage, longer operational disruption, or financial loss.

Minor: Single or minor injuries requiring first aid, cosmetic vessel damage, no or minor environmental impact, additional work, minor operational disruption, no missed voyages

Negligible: Injury not requiring first aid, no vessel damage, no environmental impact, no missed voyages

V. DESCRIPTION OF LOSS

Use the textbox to describe the loss (if there is).
In this section, it is expected to make a brief description of the loss.

VI. THE DETAILS OF INJURED PERSON

Use the textbox to indicate the details of the injured person (if there is)

In this section name, rank, date of birth, sex, nationality and other necessary information should be stated.

VII. TYPE OF HARM TO PERSON

Use the checkbox to select the type of harm to person (if there is)
The type of harm is stated as follows in OCIMF Marine Injury Reporting Guidelines (1977).

First Aid Case: This is any one-time treatment and subsequent observation or minor injuries such as bruises, splinters, scratches, burns, cuts, etc. The first aid may or may not be administered by a physician or registered professional.

It includes:

- follow-up visits to a nurse or physician for observation ONLY, or for a routine dressing change
- negative X-ray results
- use of elastic bandages
- irrigation of eye and removal of non-embedded foreign objects using a cotton swab
- cleaning abrasions/wounds with an antiseptic and applying dressing
- one-time administration of oxygen after exposure to the toxic atmosphere and resumption of normal (but not restricted) work the following day
- applying a one-off cold compress or limited soaking of a bruise
- soaking, application of hot-cold compress and use of elastic bandage on sprains and strains immediately after injury
- use of non-prescriptive medicines
- treatment of First Degree burns

Permanent Partial Disability: This is any work injury which results in the complete loss, or permanent loss of use, of any member or part of the body, or any impairment of functions of parts of the body, regardless of any pre-existing disability of the injured member or impaired body function, that partially restricts or limits an employee basis to work on a permanent basis at sea. Such an individual could be employed ashore but not at sea in line with industry guidelines.

Restricted Work Case: This is an injury, which results in a person being unable to perform all normally assigned work functions during a scheduled work shift or being assigned to another job on a temporary or permanent basis on the day following the injury.

Lost Workday Case: This is an injury which results in a person being unable to carry out any of his duties or to return to work on a scheduled work shift on the day following the injury unless caused by delays in getting medical treatment ashore.
Note: An injury is classified as an LWC if the person is discharged from the ship for medical treatment.

Permanent Total Disability: This is any work injury which incapacitates a person permanently and results in termination of employment on medical grounds (e.g. loss of limb(s) permanent brain damage, loss of sight) and precludes the individual from working either at sea or ashore.

Fatality: A death directly resulting from a work injury regardless of the length of time between the injury and death.

Medical Treatment Case: This is any work-related loss of consciousness (unless due to ill health), illness or injury requiring more than first aid treatment by a dentist, physician, surgeon or registered medical personnel, e.g. nurse or paramedic under the standing orders of a physician, or under the specific order of a physician or if at sea with no physician onboard could be considered as being in the province of a physician.

It includes:

- injuries which result in loss of consciousness, even if the individual resumes work after regaining consciousness (N.B. this does not cover loss of consciousness due to ill health);
- use of casts, splints or other means of immobilization;
- any general surgical treatment;
- use of a series of compresses for treatments of bruises, sprains or strains;
- sutures for non-cosmetic purposes;
- use of other than non-prescriptive drugs or medications;
- removal of embedded objects from the eye by surgical means;

It excludes:

- first aid, Lost Workday Case and Restricted Work Case
- a one-off tetanus injection;
- hospitalization for observation without treatment;
- consultative visit to, or examination by, a physician or registered professional for the purpose of a confirmatory check.

Other: Any other harm that you consider to be different from the above mentioned cases.

Comments: Use this section to describe the harm and additional information.

VIII. CONDITIONS & ADDITIONAL DETAILS

Use the textbox to indicate the conditions and additional information.
In this section date & time of occurrence, weather condition, sea state, ship position in Lat-Long, geographical area, loading condition of the ship, specific Location of Occurrence on board ship and other necessary information should be stated.
Ship operation area describes the circumstances where the incident occur, like for example: open sea, separation traffic, narrow channel, harbor basin, dry dock, etc

IX. DESCRIPTION OF EVENT

Use the textbox to make a description of the event. The sequence of events that preceded the incident must be indicated. If additional sheets or photographs were provided, please select the proper box.

X. WITNESS(ES) NAME & RANK

Use the textbox to give detailed information about the witness(es).

XI. ROOT CAUSE ANALYSIS

Use the Root Cause Evaluation Taxonomy given in Appendix I to indicate the causes of the occurrence. Please indicate the root causes of their unique "ID" code.

XII. CORRECTIVE ACTIONS

Use the textbox to state the corrective action to eliminate the cause of a finding. Corrective action is taken to prevent a recurrence.

XIII. PREVENTIVE ACTIONS

Use the textbox to indicate preventive actions to eliminate the cause of a potential nonconformity or other undesirable potential situation. Preventive action is taken to prevent occurrence.

XIV. LESSONS LEARNT

Use the textbox to share the lessons learned from incidents. This would help take measures to prevent any repeat of the incident.

XV. PERSON/(S) WHO CARRIED OUT ANALYSIS WITH MASTER

Use the textbox to specify the people who carried out the analysis with the Master.

XVI. FOR OFFICE USE

In this section, company remarks will be indicated.
Date received: The date on which the analysis report received by office staff.
Date closed: The date on which the case closed by office staff.
Company remarks: In this section, remarks on the incident will be given (including a description of equipment/machinery repaired, training conducted, system components developed/revised, persons responsible for monitoring, etc.).
Further Action Required: Select the appropriate box; Y for 'Yes' and N for 'No'.

3.6. Case Study

A case study was carried out on the developed accident/incident and near-miss analysis & reporting form by using the developed guideline.

Sample Case: *The ship was bound for Jetty 3/Ornek Terminal in Turkey and it was agreed with the Pilot on board that mooring lines would have been sent to shore one by one, and as per the information from Pilot, the springs to be sent via heaving lines but headlines and stern lines to be sent ashore via two mooring boats. First springs were sent ashore via heaving lines from fore and aft and the position of the vessel was adjusted. Fore and aft stations began lowering the fore and stern lines after springs were completed. The first headline was lowered to the water level and was picked up by fore mooring boat safely, was slacked continuously under the supervision of Chief Officer. At that time mooring boat was pulling the headline. When the fore mooring boat approached to the pier, the boat could not get alongside properly, and boat used astern way on its engine while the mooring line was very close to its propeller and the mooring line was entangled to its propeller at 18:20 LT on 20th May 2019. Chief Officer reported the situation to the Bridge. At the same time, the aft mooring boat was safely carrying the stern lines to the pier. Fore mooring boat's crew tried to detach the rope from the propeller but they could not succeed. Vessel's fore mooring team waited for aft mooring boat to come to bow to continue manoeuvring as per pilot's orders until 18:46 LT. Then all fast was at 18:58 LT. Fore mooring boat's crew, under the supervision of Loading Master of the Terminal, cut the mooring line approximately 10 meters from the end for freeing the boat from the ship. At the same time, some part of the tail line of the mooring line was also entangled, and the tail was not brought back to the vessel.*

An accident/incident and near miss reporting & analysis & reporting form was filled in reference with above mentioned case by using the developed guideline by an experienced Master. The filled form is given in Fig. 7.

LOGO & SHIPPING COMPANY NAME	Form No Issue Date Revision No Revision Date Issued by Approved by

ACCIDENT/INCIDENT OR NEAR-MISS ANALYSIS & REPORTING FORM

Vessel: M/T Ottoman	**Case No:** 001	**Analysis commence date:** 20.05.2019 **Analysis completed date:** 20.05.2019

Accident ☐ **Incident** ☑ **Near miss** ☐

Type of Loss

Person	☐	**Property/Asset**	☑
Environment	☐	**Process/operation/business**	☐

Loss Severity

Catastrophic	☐	**Critical**	☐	**Marginal**	☐
Minor	☐	**Negligible**	☑		

Description of loss (if there is) tail line was totally lost

Details of Injured Person

Name		**Rank**		**D.O.B.**		**Sex**		**Nationality**	
Other:									

Type of harm to person (if there is)

First Aid Case	☐	**Permanent Partial Disability**	☐	**Restricted Work Case**	☐
Lost Workday Case	☐	**Permanent Total Disability**	☐	**Fatality**	☐
Other	☐	**Medical Treatment Case**	☐		
Comments:					

Conditions & Additional Details

Date & Time of occurence	20.05.2019			**Ship position (Lat-Long)**	41°18' N-36°20 E
Ship operation area	mooring for Jetty 3/Ornek Terminal			**Geographical area**	Blacksea
Loading condition	loaded			**Specific location of occurence on board**	Forecastle
Weather		**Wind**	SSW 2	**Current**		**Visibility**	
Sea state		**Wave**					
Other:							

Description of Event

The ship was bound for Jetty 3/Ornek Terminal in Turkey and it was agreed with the Pilot on board that mooring lines would have been sent to shore one by one, and as per the information from Pilot, the springs to be sent via heaving lines but head lines and stern lines to be sent ashore via two mooring boats. First springs were sent ashore via heaving lines from fore and aft and the position of the vessel was adjusted. Fore and aft stations began lowering the fore and stern lines, after springs were completed. First head line was lowered to the water level and was picked up by fore mooring boat safely, was slacked continuously under the supervision of Chief Officer. At that time mooring boat was pulling the head line. When the fore mooring boat approached to the pier, boat could not get alongside properly, and boat used astern way on its engine while the mooring line was very close to its propeller and the mooring line was entangled to its propeller at 18:20 LT on 20th May 2019. Chief Officer reported the situation to the Bridge. At the same time aft mooring boat was safely carrying the stern lines to the pier. Fore mooring boat's crew tried to detach the rope from the propeller but they could not succeed. Vessel's fore mooring team waited for aft mooring boat to come to bow to continue maneuvering as per pilot's orders until 18:46 LT. Then all fast was at 18:58 LT. Fore mooring boat's crew, under the supervision of Loading Master of the Terminal, cut the mooring line approximately 10 meters from the end for freeing the boat from the ship. At the same time some part of the tail line of the mooring line was also entangled, and the tail was not brought back to the vessel.

Additional sheets attached	☑	**Photographs attached**	☑

Witness(es) Name & Rank:

Fig. 7. Case study analysis & reporting form

ROOT CAUSE ANALYSIS

H.2.9.1. Inadequate situational awareness H.2.6. Inadequate perception of risk J.8.10. Inadequate work planning or programming J. 12.2.2.1. Risk assessment process is inadequate

Corrective Actions

a)During waiting for the aft mooring boat to come to bow area after completing their work at aft section and then until completing the fore mooring lines and all fast, forward tugboat kept pushing the vessel alongside, b) A briefing performed with the ship master after the incident regarding safe mooring operation, c) ship crew at the fwd and aft station informed to monitor mooring ropes and slack slowly, d) Crew of the mooring boats reminded by the pilot for safe rope handling operation

Preventive Actions

a) This incident will be circulated to all fleet vessels inorder to prevent reccurence.b)Mooring boat's crew should be careful while carrying mooring line to shore and should not use or stop engine when the mooring line is too close to the propeller, c) Briefing will be conducted with the pilot prior to commence of berthing operation for safe rope handling by mooring boat crew and inform them on arrival close to berth, d)Training will be performed for all deck crew and deck officers to slowly slack and monitor ropes during berthing operation, e)Mooring lines will be lowered to the mooring boat with great care and monitor boat movements.

Lessons Learnt

a) Mooring lines should be lowered into the boat with great care and monitor boat movements. b) Mooring lines should be securely lashed by the boat crew in the moorig boat before the boat proceeds to the jetty or dolphin, this will be checked by ship officers, boat crew will be informed if unsafe conditions are observed. c) Quick release facilities of the boat should be in mind by boat crew for to relase lines in case of an emergency. d) Tidal, wind and rain conditions should be evaluated carefully and extreme caution should be taken by all involved crew.

Person/(s) who carried out analysis with Master	**MASTER**
Name & Rank	**Name**
Signature	Signature

FOR OFFICE USE

Date received	**Further Action Required?**	**Date closed**
	Y ☐ **N** ☑	
Company remarks: This incident will be circulated to all fleet vessels The incident will be added shipboard meeting agenda **Name:** **Signature:**		

Fig. 7. Case study analysis& reporting form (cont.)

4. Conclusion

In this project, we introduced an accident/incident and near miss analysis & reporting form which is not designed for a specific ship type or ship operation. Our project proposal was covering accident and incident cases. However, by reviewing the output of workshops, the need for a proactive approach arise. So we included near-miss event to the project studies and an accident/incident and near miss analysis & reporting form structure was designed.

To improve project outcomes in the maritime domain, two workshops were held. A network for the working group and sub working group of shipping companies operating different types of ships in international waters was established. A literature review was applied, accident investigation boards' recent investigation reports were reviewed and accident analysis forms of different shipping companies were examined.

In the literature, a taxonomy accepted as a standard in the maritime field is not available, yet. In this project, we applied a method of classification that is based on evaluations of terminology lists with feedback from experts who would use the taxonomy. Developed root cause evaluation taxonomy was validated by the project staff. For every category and root cause, there's a unique "ID" code to make it easy to cite, 'H' for human factors and 'J' for Job related factors. After taxonomy development studies, the final version of the standard analysis & reporting form was generated and validated upon applying in maritime accident/incidents and through statistical analysis based on expert opinion. Following, a guideline containing information regarding the standard analysis & reporting form was prepared.

It is very important to adopt a proactive approach in the maritime domain. We tried to achieve this through including near-miss events to the analysis process. We have carried out this novel study to ensure safe data transfer between shipping companies.

Taking into consideration the contributions introduced by this project and needs of the maritime sector as well, this form can be converted into a format that is processed by the computer automatically in the future. It can thus become time-saving and easier to be adopted by maritime companies.

The proposed standard accident/incident & near-miss analysis and reporting form will bring a common understanding to the analysis of the occurrences on board vessels. This form, which will be used in reporting to the company as well, will raise awareness of accident analysis. Analysis of the accidents occurring on board ships of different companies with a standard form will be useful for information sharing and lessons learned. Since it also brings a standardization in root cause terminology, it is anticipated that it will contribute to the improvement in control and prevention of occurrences. The proposed form, which can be updated according to the national legal regulations of the countries, can be considered as a reference format. With reference to this form, each country can be encouraged to use a standard format in its merchant fleet. In addition, in order to further develop the method to be used in the root cause analysis section, a different joint project study can be carried out with different countries.

The outputs of this project will serve as an example to fit existing maritime accident/incident &near-miss analysis & reporting to a certain standard. In the next step, if the research findings are evaluated by IMO, all the work carried out in this study will contribute to the development of safety culture in the maritime domain.

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Attachment

Attachment 1

ACCIDENT/INCIDENT OR NEAR-MISS ANALYSIS & REPORTING FORM

LOGO & SHIPPING COMPANY NAME	Form No Issue Date Revision No Revision Date Issued by Approved by

ACCIDENT/INCIDENT OR NEAR MISS ANALYSIS& REPORTING FORM

Vessel:	Case No:	Analysis commence date: Analysis completed date:

Accident ☐ **Incident** ☐ **Near miss** ☐

Type of Loss

Person	☐	**Property/Asset**	☐
Environment	☐	**Process/operation/business**	☐

Loss Severity

Catastrophic	☐	**Critical**	☐	**Marginal**	☐
Minor	☐	**Negligible**	☐		

Description of loss (if there is)

Details of Injured Person

Name		**Rank**		**D.O.B.**		**Sex**		**Nationality**	
Other:									

Type of harm to person (if there is)

First Aid Case	☐	**Permanent Partial Disability**	☐	**Restricted Work Case**	☐
Lost Workday Case	☐	**Permanent Total Disability**	☐	**Fatality**	☐
Other	☐	**Medical Treatment Case**	☐		

Comments:

Conditions & Additional Details

Date & Time of occurence				**Ship position (Lat-Long)**			
Ship operation area				**Geographical area**			
Loading condition		**Specific location of occurence on board**					
Weather		**Wind**		**Current**		**Visibility**	
Sea state		**Wave**					
Other:							

Description of Event

Additional sheets attached ☐	**Photographs attached** ☐

Witness(es) Name & Rank:

ROOT CAUSE ANALYSIS

Corrective Actions

Preventive Actions

Lessons Learnt

Person/(s) who carried out analysis with Master	**MASTER**
Name & Rank	Name Signature

FOR OFFICE USE

Date received	**Further Action Required?**	**Date closed**
	Y ☐ **N** ☐	
Company remarks: **Name:** **Signature:**		

Attachment 2

REFERENCE GUIDELINE FOR USE OF ACCIDENT/INCIDENT OR NEAR-MISS ANALYSIS & REPORTING FORM

When an incident/accident or near miss occurs, you must immediately analyze the occurrence to identify unsafe acts, conditions or procedures, as far as possible, to ensure that work can be done safely. The information about the use of the analysis & reporting form to be completed is given below.

XVII. Occurrence descriptive information takes place on the top of the analysis & reporting form.

Vessel: Vessel name must be indicated on the form.
Case no: Use the space to assign a unique case number to each individual accident.
Analysis commences date: Use the space to indicate the date on which the analysis started. Do not confuse with the date of occurrence or the date on which the analysis completed.
Analysis completed date: Use the space to indicate the date on which the analysis completed.

XVIII. Use the checkbox to select the type of occurrence.

Accident: Occurrence which has inadvertently caused a loss or hazard to life, property, and environment, is called an accident.
An accident does not include a deliberate act or omission, with the intention to cause harm to an individual, the environment or the safety of a ship.

Incident: According to Res. MSC.255(84), a marine incident means an event, or sequence of events, other than a marine casualty, which has occurred directly in connection with the operations of a vessel that endangered, or, if not corrected, would endanger the safety of the ship, its occupants or any other person or the environment.
A marine incident does not include a deliberate act or omission, with the intention to cause harm to an individual, the environment or the safety of a ship.

Near Miss: As stated in MSC-MEPC.7/Circ.7 a near-miss means a sequence of events and/or conditions that could have resulted in a loss. This loss was prevented only by a fortuitous break in the chain of events and/or conditions. The potential loss could be an injury, environmental damage, or negative business impact (e.g., repair or replacement costs, contract violations, loss of reputation, scheduling delays).
Some examples of a near-miss given in (MSC-MEPC.7/Circ.7) help to illustrate this definition:

- Any occurrence that leads to the implementation of an emergency procedure, plan or response and thus prevents a loss. For instance, a collision is narrowly avoided; or a crew member double checks a valve and discovers a wrong pressure reading on the supply side.
- Any occurrence where an unexpected condition could lead to an adverse consequence, but which does not occur. For instance, a person moves from a location immediately before a crane unexpectedly drops a load of cargo there; or a ship finds itself off-course in normally shallow waters but does not ground because of an unusual high-spring tide.
- Any dangerous situation or condition that is not discovered until after the danger has passed. For instance, a vessel safely departs a port of call and discovers several hours into the voyage that the ships radio was not tuned to the Harbour Masters radio frequency; or it is discovered

that ECDIS displays scale does not match the scale, projection, or orientation of the chart and radar images.

XIX. TYPE OF LOSS

Use the checkbox to select the type of loss.

The loss means any hazard to human life, property or environment is called a Loss. Obvious losses are mostly those of life, environment, and property, however, a loss may also be not obvious, which are, for instance;

- Loss of reputation
- Interruption or suspension of an operation
- Scheduling delays
- Time loss, and
- Consequences of all above

Losses may be incurred immediately after an incident or further after a certain period.

XX. LOSS SEVERITY

Use the checkbox to select the loss severity.

Catastrophic: Multiple fatalities, total loss of the ship, or extreme environmental impact

Critical: Single-fatality, disabling injury or illness, major vessel damage, major environmental impact, or business downtime.

Marginal: Multiple or severe Injuries requiring more than first aid, local vessel damage, some environmental damage, longer operational disruption, or financial loss.

Minor: Single or minor injuries requiring first aid, cosmetic vessel damage, no or minor environmental impact, additional work, minor operational disruption, no missed voyages

Negligible: Injury not requiring first aid, no vessel damage, no environmental impact, no missed voyages

XXI. DESCRIPTION OF LOSS

Use the textbox to describe the loss (if there is).
In this section, it is expected to make a brief description of the loss.

XXII. THE DETAILS OF INJURED PERSON

Use the textbox to indicate the details of the injured person (if there is)
In this section name, rank, date of birth, sex, nationality and other necessary information should be stated.

XXIII. TYPE OF HARM TO PERSON

Use the checkbox to select the type of harm to person (if there is)
The type of harm is stated as follows in OCIMF Marine Injury Reporting Guidelines (1977).

First Aid Case: This is any one-time treatment and subsequent observation or minor injuries such as bruises, splinters, scratches, burns, cuts, etc. The first aid may or may not be administered by a physician or registered professional.

It includes:

- follow-up visits to a nurse or physician for observation ONLY, or for a routine dressing change
- negative X-ray results
- use of elastic bandages
- irrigation of eye and removal of non-embedded foreign objects using a cotton swab
- cleaning abrasions/wounds with an antiseptic and applying dressing
- one-time administration of oxygen after exposure to the toxic atmosphere and resumption of normal (but not restricted) work the following day
- applying a one-off cold compress or limited soaking of a bruise
- soaking, application of hot-cold compress and use of elastic bandage on sprains and strains immediately after injury
- use of non-prescriptive medicines
- treatment of First Degree burns

Permanent Partial Disability: This is any work injury which results in the complete loss, or permanent loss of use, of any member or part of the body, or any impairment of functions of parts of the body, regardless of any pre-existing disability of the injured member or impaired body function, that partially restricts or limits an employee basis to work on a permanent basis at sea. Such an individual could be employed ashore but not at sea in line with industry guidelines.

Restricted Work Case: This is an injury, which results in a person being unable to perform all normally assigned work functions during a scheduled work shift or being assigned to another job on a temporary or permanent basis on the day following the injury.

Lost Workday Case: This is an injury which results in a person being unable to carry out any of his duties or to return to work on a scheduled work shift on the day following the injury unless caused by delays in getting medical treatment ashore.
Note: An injury is classified as an LWC if the person is discharged from the ship for medical treatment.

Permanent Total Disability: This is any work injury which incapacitates a person permanently and results in termination of employment on medical grounds (e.g. loss of limb(s) permanent brain damage, loss of sight) and precludes the individual from working either at sea or ashore.

Fatality: A death directly resulting from a work injury regardless of the length of time between the injury and death.

Medical Treatment Case: This is any work-related loss of consciousness (unless due to ill health), illness or injury requiring more than first aid treatment by a dentist, physician, surgeon or registered

medical personnel, e.g. nurse or paramedic under the standing orders of a physician, or under the specific order of a physician or if at sea with no physician onboard could be considered as being in the province of a physician.

It includes:

- injuries which result in loss of consciousness, even if the individual resumes work after regaining consciousness (N.B. this does not cover loss of consciousness due to ill health);
- use of casts, splints or other means of immobilization;
- any general surgical treatment;
- use of a series of compresses for treatments of bruises, sprains or strains;
- sutures for non-cosmetic purposes;
- use of other than non-prescriptive drugs or medications;
- removal of embedded objects from the eye by surgical means;

It excludes:

- first aid, Lost Workday Case and Restricted Work Case
- a one-off tetanus injection;
- hospitalization for observation without treatment;
- consultative visit to, or examination by, a physician or registered professional for the purpose of a confirmatory check.

Other: Any other harm that you consider to be different from the above mentioned cases.

Comments: Use this section to describe the harm and additional information.

XXIV. CONDITIONS & ADDITIONAL DETAILS

Use the textbox to indicate the conditions and additional information.
In this section date & time of occurrence, weather condition, sea state, ship position in Lat-Long, geographical area, loading condition of the ship, specific Location of Occurrence on board ship and other necessary information should be stated.
Ship operation area describes the circumstances where the incident occur, like for example: open sea, separation traffic, narrow channel, harbour basin, dry dock, etc

XXV. DESCRIPTION OF EVENT

Use the textbox to make a description of the event. The sequence of events that preceded the incident must be indicated. If additional sheets or photographs were provided, please select the proper box.

XXVI. WITNESS(ES) NAME & RANK

Use the textbox to give detailed information about the witness(es).

XXVII. ROOT CAUSE ANALYSIS

Use the Root Cause Evaluation Taxonomy given in Appendix I to indicate the causes of the occurrence. Please indicate the root causes of their unique “ID” code.

XXVIII. CORRECTIVE ACTIONS

Use the textbox to state the corrective action to eliminate the cause of a finding. Corrective action is taken to prevent a recurrence.

XXIX. PREVENTIVE ACTIONS

Use the textbox to indicate preventive actions to eliminate the cause of a potential nonconformity or other undesirable potential situation. Preventive action is taken to prevent occurrence.

XXX. LESSONS LEARNT

Use the textbox to share the lessons learned from incidents. This would help taking measures to prevent any repeat of the incident.

XXXI. PERSON/(S) WHO CARRIED OUT ANALYSIS WITH MASTER

Use the textbox to specify the people who carried out the analysis with the Master.

XXXII. FOR OFFICE USE

In this section, company remarks will be indicated.
Date received: The date on which the analysis report received by office staff.
Date closed: The date on which the case closed by office staff.
Company remarks: In this section, remarks on the incident will be given (including a description of equipment/machinery repaired, training conducted, system components developed/revised, persons responsible for monitoring, etc.).
Further Action Required: Select the appropriate box; Y for 'Yes' and N for 'No'.

Annex I of Attachment 2

HUMAN RELATED FACTORS

H1. Human Behaviour
- 1.1. Culture
- 1.2. Character
- 1.3. Lack of self-discipline

H2. Human Characteristics
- 2.1. Low learning aptitude
- 2.2. Competence
- 2.3. Uncommunicativeness
- 2.4. Complacency
- 2.5. Slow reaction time
- 2.6. Inadequate perception of risk
- 2.7. Less than optimal working relationships
- 2.8. Vigilance
- 2.9. Inattention
  - 2.9.1. Inadequate situational awareness
  - 2.9.2. Attention diverted by non-work related issues

H3. Physical/Physiological Capacity-Stress
- 3.1. Sensory deficiencies
  - 3.1.1. Vision/hearing deficiency
  - 3.1.2. Other sensory deficiencies (touch, smell, taste, balance)
- 3.2. Sensitivity
  - 3.2.1. Substance sensitivities or allergies
  - 3.2.2. Sensitivities to temperature, sound, etc.
- 3.3. Temporary/permanent disabilities
- 3.4. Alcohol/drug use
- 3.5. Injury or illness
- 3.6. Temporary deviation in blood pressure/glucose
- 3.7. Seasickness
- 3.8. Inappropriate height, weight, size, strength, reach, etc.
- 3.9. Fatigue
  - 3.9.1. Fatigue due to task load or duration
  - 3.9.2. Fatigue due to lack of rest
  - 3.9.3. Fatigue due to sensory overload
  - 3.9.4. Fatigue due to extreme concentration/perception demands
  - 3.9.5. Routine, monotony, demand for uneventful vigilance
  - 3.9.6. Extreme judgement/decision demands

H4. Psychological capacity- stress
- 4.1. Mental/emotional illness
- 4.2. Panic
- 4.3. Fears and phobias
- 4.4. Inappropriate aggression
- 4.5. Frustration
- 4.6. Pre-occupation with problems
- 4.7. Emotional load
- 4.8. Time pressure

H5. Inadequate Knowledge, Skill, Training
- 5.1. Inadequate practice
- 5.2. Insufficient knowledge of the vessel's system/equipment

5.3. Inadequate technical knowledge
5.4. Inadequate update training
5.5. Inadequate initial training
5.6. Inadequate orientation of working environment
5.7. Lack of experience
5.8. Lack of team training (BRM/BTM)
5.9. Inadequate knowledge of regulations/standards
5.10. Inadequate knowledge of ship operations
5.11. Poor decision making/information use

H6. Factors for Lack of Motivation

6.1. Lack of incentives
6.2. Proper performance is punished
6.3. Improper performance is tolerated
6.4. Peer pressure among ship crew
6.5. Improper attempt to gain attention
6.6. Inadequate performance measurement
6.6.1. Inadequate performance feedback
6.6.2. Inadequate performance measurement and evaluation
6.7. Hierarchical pressure

JOB RELATED FACTORS

J7. Communication Problems

7.1. Inadequate communication
7.1.1. Inadequate communication between ships
7.1.2. Inadequate communication between ship and shore
7.1.3. Inadequate communication between crew members
7.1.4. Inadequate communication between shipping company and 3rd party
7.2. Language difficulties
7.3. Misunderstanding
7.4. Speech interference
7.5. SMCP not used
7.6. Problem with communication equipment itself

J8. Inadequate Leadership

8.1. Unclear or conflicting reporting relationships
8.2. Inadequate initial instructions
8.3. Lack of coaching
8.4. Inadequate review of instruction
8.5. Lack of supervisory/management job knowledge
8.6. Lack of discipline crew/passenger
8.7. Improper or insufficient delegation
8.8. Unclear or conflicting assignment of responsibility
8.9. Improper supervisory example
8.10. Inadequate work planning or programming
8.11. Insufficient manpower utilized for the task

J9. Inadequate Team Culture

9.1. Absence of shared mental model
9.2. Ineffective BRM
9.3. Lack of ownership
9.4. Over-reliance on people, equipment or system
9.4.1. Over-reliance on system/equipment
9.4.2. Over- reliance on people/supervisor

J10. Safety Related Issues
- 10.1. Lack of safety culture
- 10.2. Unsafe acts
  - 10.2.1. Unintended actions
    - 10.2.1.1. Mistiming
    - 10.2.1.2. Misordering
    - 10.2.1.3. Memory failures
    - 10.2.1.4. Overlook
  - 10.2.2. Intended actions
    - 10.2.2.1. Improper attempt to save effort
    - 10.2.2.2. Improper attempt to avoid discomfort
- 10.3. Sabotage

J11. Inadequate Manning Level

J12. Problems Related to System and/or Its Application
- 12.1. Procedure, rules and standards
  - 12.1.1. Problems related to procedure and/or its application
    - 12.1.1.1. Absence of company procedures
    - 12.1.1.2. Company procedures does not meet legislative requirements
    - 12.1.1.3. Discrepancies between procedures
    - 12.1.1.4. Misapplication of procedures
    - 12.1.1.5. Inadequate update of procedures
  - 12.1.2. Problems related to Rules, standards, regulations and policies
    - 12.1.2.1. Absence of rules, regulations, policies, standards
    - 12.1.2.2. Misapplication of rules, regulations, policies, standards
    - 12.1.2.3. Poor/ambiguous rules, regulations, policies, standards
    - 12.1.2.4. Increasing international rules
    - 12.1.2.5. Absence of Classification society rules/guidelines
    - 12.1.2.6. Problems related to Working standards
      - 12.1.2.6.1. Inadequate development of working standards
      - 12.1.2.6.2. Inadequate communication of working standards
      - 12.1.2.6.3. Inadequate maintenance of working standards
      - 12.1.2.6.4. Inadequate monitoring of compliance of work standards
- 12.2. Problems related to management
  - 12.2.1. Inadequate company system management
    - 12.2.1.1. Lack of corrective actions taken
    - 12.2.1.2. Inadequate company standing orders
    - 12.2.1.3. Inadequacy in keeping/preserving documents orderly
    - 12.2.1.4. Certification fraud
    - 12.2.1.5. Inadequate inspection
    - 12.2.1.6. Inadequate warning system
    - 12.2.1.7. Providing inadequate reference documents, directives and guidance publications
  - 12.2.2. Inadequate risk assessment
    - 12.2.2.1. Risk assessment process is inadequate
    - 12.2.2.2. Risk assessment process not implemented
    - 12.2.2.3. Taking ineffective risk related precautions

J13. Inadequacy in Ship Construction, Design and Equipment
- 13.1. Inadequacy in ship construction and design
  - 13.1.1. Inadequate consideration of human factors/ergonomics
  - 13.1.2. Inadequate monitoring & evaluation of changes

13.1.3. Inadequate assessment of operational readiness
13.1.4. Assembly defect in construction
13.1.5. Construction defect
13.1.6. Design inadequate
13.1.7. Construction material select defect

13.2. Material/mechanical failure
13.2.1. Brittle fracture of equipment
13.2.2. Cavitation damage
13.2.3. Corrosion
13.2.4. Casting defect
13.2.5. Gross plastic deformation
13.2.6. Seal/gasket defect
13.2.7. Material fatigue
13.2.8. Worn out of equipment
13.2.9. Weld defect
13.2.10. U.V. /Chemical deterioration

13.3. Inadequate material/equipment
13.3.1. Equipment poorly designed
13.3.2. Equipment not operational
13.3.3. Computer based systems are not logic
13.3.4. Equipment/tool/material misuse
13.3.5. Inadequate removal and replacement of unsuitable tools/equipment
13.3.6. Inadequate availability of tools/equipment
13.3.7. Inadequate standards and specifications of tools/equipment
13.3.8. Equipment/ Material select defect
13.3.9. Equipment used by unauthorized person

13.4. Inadequate maintenance
13.4.1. Inadequate preventive assessment of maintenance needs
13.4.2. Inadequate reparative communication of maintenance needs
13.4.3. Inadequate adjustment/repair/maintenance of tools/equipment
13.4.4. Inappropriate temporary repairs
13.4.5. Inadequate inspection/monitoring of equipment
13.4.6. Inadequate salvage and reclamation of tools/equipment

13.5. Problem with ship handling characteristics

13.6. Inadequate purchasing
13.6.1. Inadequate contractor selection
13.6.2. Inadequate specifications on requisitions
13.6.3. Inadequate research on material/equipment
13.6.4. Inadequate mode or route of shipment
13.6.5. Inadequate communication of safety and health data
13.6.6. Improper handling of materials
13.6.7. Improper storage of materials

J14. Cargo Related Issues

14.1. Cargo deterioration
14.2. Cargo self-ignition
14.3. Cargo interaction
14.4. Radiation

J15. Environmental Factors

15.1. Natural environment
15.1.1. Current
15.1.2. Heavy weather

15.1.3 Tide
15.1.4. Abnormal waves
15.1.5. Natural disasters
15.1.6. Hazardous natural environment
15.1.7. Ice
15.1.8. Temperature extremes
15.1.9. Humidity
15.1.10. Visual environment/lightning

15.2. External environment
15.2.1. Own vessel's rope/net
15.2.2. Other vessel's rope/net
15.2.3. Flying objects
15.2.4. Floating objects
15.2.5. Other vessels
15.2.6. Uncharted underwater obstruction
15.2.7. Intense vessel traffic

15.3. Working environment
15.3.1. Noise
15.3.2. Vibration
15.3.3. Poor housekeeping
15.3.4. Unclean working place (tank etc.)
15.3.5. Poor or excessive lightening of working place
15.3.6. Inadequate ventilation

J16. Third Party Related Factors

16.1. Manufacturer did not provide sufficient guidance
16.2. Inadequate navigational information provided/demand
16.2.1. VTS not provided/requested information
16.2.2. Appropriate information not provided by/requested from the regional authority
16.3. Tug related deficiencies
16.4. Pilotage related deficiencies
16.5. Inadequate Flag state/ port state inspection
16.6. Custom procedure deficiencies

J17. Commercial Pressure

International Association of Maritime Universities

Meiwa Building 8F, 1-15-10 Toranomon, Minato-ku, Tokyo 105-0001, Japan

Tel : 81-3-6257-1812 E-mail : info@iamu-edu.org URL : http://www.iamu-edu.org

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