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Investigating the Impact of Bridge Resource Management on Navigational Safety by Root Cause Analysis

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Abstract

Maritime transportation is a cost-effective and environmentally friendly method of transporting goods between different continents and geographies. It is a more economical means of unit transportation than road transportation. Nevertheless, the growth in maritime traffic and the advent of larger vessels may result in more severe consequences in the event of an accident. At this juncture, the most crucial instrument for averting further potential incidents is to ascertain the underlying causes of recent accidents. In this study, the M/V VITASPIRIT accident is examined through a root cause analysis utilizing the 5 Why technique and a fishbone diagram. The study results demonstrated that communication and awareness, as they pertain to human factors, are the primary dynamics influencing the accident process. Furthermore, it has been observed that effective bridge resource management represents a strategic tool for preventing maritime accidents. With the results obtained, the objective is to raise awareness regarding the prevention of similar accidents that may occur in the region and to create a reference source for policymakers to develop measures to enhance navigational safety.

Keywords: Root cause analysis, 5 Why technique, fishbone diagram, maritime transportation, navigational safety

1. Introduction

First-degree bridge resource management (BRM) is a management concept that ensures the safe and systematic organisation of ship operations. At this juncture, BRM can be defined as the meticulous planning, organisation and effective management of human, information/enformation and equipment resources that converge on the bridge with a view to ensuring the safety of navigation [1]. The conceptual framework of BRM is based on the principle that navigational safety is dependent on a multitude of individual and organisational factors, the prediction and planning of which should occur in advance. Consequently, BRM commences with the pre-voyage planning phase and culminates in the conclusion of the voyage, encompassing information gathering, dissemination and evaluation processes [2]. BRM discussions highlighted emphasise the importance of organising personnel on board in a way that ensures the effective use of bridge resources, with the aim of reducing the risk of accidents [3]. Accordingly, BRM represents an analytical methodology that can be employed

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to predict or avoid the ship encountering difficulties caused by the human factor. For BRM to function effectively, it is essential that the individuals in the team observe and follow each other's actions/inactions and reach the right conclusion by cross-checking. In other words, BRM aims to provide the skills necessary for the effective management of bridge and ship resources, functional task distribution and the ability of personnel to take timely and correct action against all situations that may be encountered at sea [4].

The implementation of BRM facilitates the execution of maritime operations in a safer and more efficient manner. This is achieved by addressing deficiencies and weaknesses within the operational framework, optimising the utilisation of available resources, and enhancing the effectiveness of processes, systems, and procedures. BRM contributes to the implementation of measures designed to minimise or eliminate the potential causes of accidents by preventing the occurrence of errors in decision-making [1]. In addition to the management of operational tasks, BRM places an emphasis on the management of risk, taking into account the emotional, cognitive and behavioural aspects inherent to the human factor. The reduction of stress and the effective functioning of the decision-making mechanism represent key target outputs of BRM. The acquisition of BRM skills by the bridge crew is essential for the efficient performance of their duties, the formulation of appropriate decisions and the safe navigation of the vessel.

The most fundamental element of the decision-making process is the identification of the root causes of the problem. Root cause analysis (RCA) is a methodology designed to diagnose the underlying causes of a problem or event and to prevent similar situations from recurring. Furthermore, this facilitates the formulation of recommendations and solutions [5]. Nevertheless, RCA has been demonstrated to be an effective tool in the context of near-miss scenarios [6]. The process of RCA entails the collection of data, the establishment of a causal table, the identification of the root cause, and the formulation and implementation of recommendations. As it is not feasible to ascertain causal factors in the absence of comprehensive information regarding the circumstances in question, the initial stage of the analysis is the collection of data. Subsequently, a causal factor chart is constructed, which organises the information obtained. A causal factor diagram is, in its most general sense, a series of diagrams that employ logical tests to elucidate the circumstances that precipitated the problem or event and the conditions that surrounded it. The subsequent phase is the identification of the root cause underlying the aforementioned causal factors. At this juncture, decision diagrams, referred to as root cause maps, serve to structure the reasoning process of decision-makers, facilitating the identification of root causes. The final stage of the analysis is the formulation of recommendations and solutions aimed at preventing the recurrence of the problem/incident in accordance with the identified root causes [7].

In recent times, there has been a notable increase in the significance attributed to RCA within the academic literature, particularly in the context of case studies within disciplines such as maritime and aviation. The analysis of actual accidents is essential for the formulation of inferences aimed at accident prevention [8]. In other words, accidents can only be prevented when they are correctly defined and understood [9,10]. At this juncture, the analysis of past accidents is of paramount importance for the development of strategic measures to prevent potential future accidents. In this study, the hypothesis that BRM is an effective tool in preventing maritime accidents is investigated and its impact on the safety of navigation is examined through RCA based on a real maritime accident.

1.1. Literature Review

In the existing literature, BRM was initially designed with the objective of strengthening the relationship between the master and pilot. However, it soon evolved into a safety culture that addresses the human factor in terms of performance and safety [11]. A study on safety culture and hazard risk perception was conducted with the participation of 77 pilots in Australia and New Zealand. The study emphasised that when a pilot is present on the bridge, which is essentially an onboard working environment, there should be a shared sense of purpose between the master, bridge crew and pilot [12]. In a further study examining the role of human factors and BRM in reducing maritime accidents, it was emphasised that crew resource management (CRM) is fundamental to improve and increase the operational efficiency of shipping. Furthermore, CRM/BRM training is now regarded as an essential component of the human error management perspective [13]. In the study on human and organisational factors in maritime accidents, the Human Factors Analysis and Classification System (HFACS) was employed as a methodology for the analysis of collision accidents reported by the UK Marine Accident Investigation Branch (MAIB). The analysis demonstrated that the majority of collisions were attributable to flawed decision-making processes and underscored the influence of environmental factors (restricted visibility, misuse of equipment), operator conditions (loss of situational awareness, lack of attention) and personnel factors (deficiencies in inter-ship communication and BRM). In consequence, the inefficient management of bridge resources is characterised by a lack of coordination among crew members, a deficiency in situational awareness and communication problems. The study highlighted the significance of BRM in navigational scenarios under pilotage in restricted waters and underscored the pivotal role of the Safety Management System in high-risk situations in offshore navigation [14]. Another study employed the Analytic Hierarchy Process (AHP) to analyse grounding type accidents. Obtained findings indicated that the primary causes of such accidents are deficiencies in communication and coordination within the scope of BRM, position calculation errors, inadequate lookout, errors in interpreting events, ineffective use of charts, inefficient use of bridge equipment and burnout in personnel. The study concluded that improvements should be made to training and education, with a particular focus on ECDIS training, which should be made compulsory and improved. Additionally, the regulation of the crew's working and resting hours, as specified in the STCW Code, should be given greater consideration [15]. Another study defined the maritime accident phenomenon as a problem in a holistic framework and proposed a RCA approach for solution [9]. A Fuzzy FTA has been conducted for marine accidents in the Arctic between 1993 and 2011. In this context, analysing 65 reported accidents/incidents based on the MAIB report. The results of the study showed that personal injury was the most frequently observed incident, while injury due to personal negligence had the highest priority among the main causes of marine accidents [16]. HFACS-Fuzzy Cognitive Mapping was used for fire prevention modeling on ships. The study drew attention to the creation of a proactive fire safety model, the importance of consistent prediction of root causes, the production of intelligent fire systems and the human factor [17]. SHip Accident Root cause Evaluation (SHARE) technique was used for RCA of ship accidents. As a result of this study, a taxonomy that provides standardization in the expression of root causes was developed and a reference methodology was obtained by applying the fuzzy SWOT (strengths, weaknesses, opportunities, and threats) / AHP method in SHARE. The research provides a model for standardizing the existing ship accident investigation and investigation reports [18]. The role of accident analysis methods on accident causation was investigated and presented a systematic review of applications between 1990 and 2018 [19]. Qualitative and quantitative syntheses of the study results were performed for Accimap, HFACS, Systems Theoretic Accident Model and Processes (STAMP) - Causal Analysis based on STAMP and functional resonance analysis method (FRAM). The results highlighted the need to develop new accident analysis approaches in the context of safety science. In another study focusing on BRM based on safety of navigation, a risk assessment of the human error factor in oil tanker collisions using Fault Tree Analysis and Cognitive Reliability Error Analysis method was proposed. Thirty nine experts participated in the study and provided their expert opinions, especially for the navigation of oil tankers around Taiwan waters. The results of the study showed that lack of communication in BRM, lack of communication between ships, fatigue, and violation of navigation rules increase the likelihood of collision-type accidents on oil tankers [20]. HFACS and FTA model were used for collision risk factors analysis of icebreaker assistance in ice-covered waters. Within the scope of the study, the collision risk factors were classified according to the HFACS-SIBCI (ship collision accidents between assisted ships and icebreakers in ice-covered waters) model and the fault tree model was proposed to analyze the collision risk factors under icebreaker assistance [21]. A dynamic Bayesian Network (BN) model was proposed for ship-ice collision risk in Arctic waters. The results of the study pointed out that the main risk factors in the region are location, weather, icing and speed [22]. Another study have highlighted the importance of BRM to avoid maritime accidents caused by human error and emphasized that dysfunctional BRM is an influential factor in the joint errors of pilot/bridge personnel. The results of the study showed that pilot errors are mostly caused by poor communication and pointed out that passage planning should be discussed in pilotage waters before the pilot joins the ship [23]. Other study have evaluated whether applying BRM to simulator-based maritime training is effective in improving non-technical skills and navigational performance. Non-technical skills were evaluated as team communication, decision-making, situational awareness, leadership and management skills for effective utilization of all available technical and personal resources during routine operations and emergencies. As a result of the study, it was observed that the BRM trainings improved the attitudes, behaviors and performance of the training participants regarding BRM [24]. Another study examined Arctic shipping in terms of risk management. In this context, navigational factors affecting accident risk were investigated using bibliometric and systematic perspectives. The results of the study showed that the risk models and their underlying evidence were explained by linear accident causality models such as HFACS, FTA and BN [25]. FRAM was used in a real maritime accident and analyzed the M/T PRESTIGE ship accident as a case study. The obtained results provided a comprehensive analysis of marine accidents, focusing on the functions and variabilities of the systems, and provided a functional tool to analyze the ship operations that cause accidents. However, it is recommended to integrate FRAM with other methods to obtain higher resolution results [26]. A BN-based emergency decision-making model was developed for collision-type accidents in the Yangtze River. Offering intuitive representation, easy implementation, and the ability to deal with incomplete and updated information, the study presented a practical and novel decision-making method for conflict-type accidents [27]. A framework was proposed for quantitative analysis of the causality of grounding accidents in Arctic shipping. Within the scope of the study, the potential risk factors of grounding type accidents were identified and the interrelationship of these factors was reflected using the AcciMap model. Critical risk factors were identified for quantitative analysis using the BN model and risk control options-*RCOs* were proposed to reduce the risk of grounding of ships in Arctic shipping [28]. Collision type accidents were analyzed using by FTA and multiple correspondence analysis. In this context, 513 collision accidents for all ship types between 1977 and 2022 were analyzed and importance and probability values were calculated for the primary causes of accidents. With the results of the study, the most violated COLREG Rules were determined and recommendations were made to reduce potential collision type accidents [29]. A risk assessment of ship steering gear failures was conducted using by Fuzzy BN. The study results depicted a valid probabilistic effect of root causes and emphasized the importance of line components in mechanical/electrical failures [30]. A data-driven BN for risk analysis of global marine accidents was developed. The results showed that the six most important risk factors affecting maritime accidents are ship type, ship operation, voyage region, deadweight, ship length and machinery power [8].

According to the data of the European Maritime Safety Agency, the biggest share in maritime accidents occurring between 2014 and 2021 was determined as the human factor with 81.1% [31]. Considering that 80% of the world's trade is carried out by sea [32], the importance of measures to increase the safety of navigation emerges [33,34]. Determining the root causes of recent maritime accidents is critical for developing effective measures to prevent possible accidents with a similar profile. At this point, BRM becomes a strategic tool in terms of increasing navigational safety by organizing ship employees to take the right actions at the right time both individually and as a team member. BRM, which refers to the effective management of bridge resources in terms of people, information and equipment, evaluates the main elements of human error within the framework of safety of navigation within the scope of miscommunication / inadequate English, over fatigue (burnout syndrome) and situational awareness. In this study, the effect of BRM on navigational safety has been investigated and the M/V VITASPRIT accident has been analyzed by using the 5 Why technique and fishbone diagram within the scope of RCA. It is aimed to provide a holistic perspective to the reader by schematizing the accident and its possible causes in a single location and providing a visual tool that structures the solution process with cause and effect relationships. In addition, it is thought that the root causes obtained will also be a reference source for policy makers to develop measures to increase the safety of navigation in order to prevent accidents with a similar profile that may occur in the region.

2. Materials and Methods

This study employed a RCA utilising the 5 Why technique and fishbone diagram to investigate the M/V VITASPIRIT accident that occurred in the İstanbul Strait. In the course of this research, the final investigation report of the Ministry of Transport and Infrastructure of the Republic of Türkiye Transportation Safety Investigation Center for serious maritime accidents was taken as a reference, and the findings of the accident were evaluated in terms of the impact of BRM on the safety of navigation. This evaluation was conducted using the structured interview technique, with the participation of six masters and three chief engineers.

The 5 Why technique, initially conceptualised by Sakichi Toyoda in 1958, entails a progressive questioning process whereby the "why" question is repeatedly posed [35-37]. In other words, the 5 Why technique, which is based on repeatedly asking the question "Why?" to the problem, involves asking and answering the question as many times as necessary to identify the root cause or the end of the causal chain [38]. The objective of the 5 Why technique is to identify the root cause by elucidating the cause-and-effect relationships associated with the problem. Once the potential causes of the problem have been identified, the "why" question can be posed five times in succession to create a strategic roadmap to the root cause. The number of repetitions may vary, depending on the nature of the problem [39]. The technique is illustrated in Figure 1.

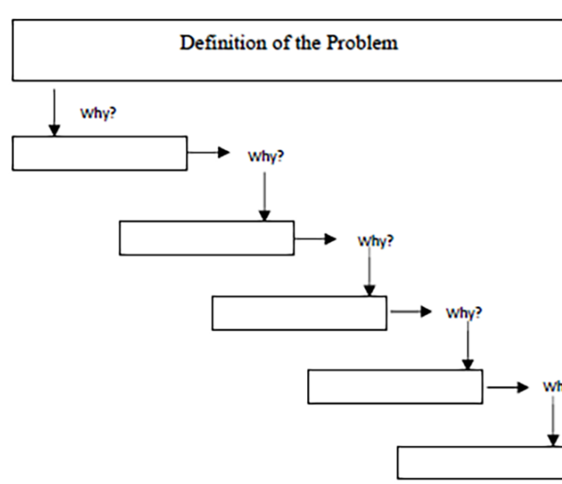

Figure 1. 5 Why technique process [40].

Another frequently utilised RCA technique in the literature is the fishbone diagram, also known as cause and effect analysis. This is often employed in conjunction with the 5 Why technique. The fishbone diagram, developed by Kaoru Ishikawa in 1942, is a technique for classifying factors affecting a problem by defining the relationships between causes and effects [36,37].

A fishbone diagram is a decision-making technique that is used to identify the potential causes of a specific event, situation, or problem. It is based on the principle of revealing the factors that contribute to the problem and identifying and improving the factor that has the most significant impact on the result [41-43]. The diagram offers the advantage of visually representing multiple causes of a problem, facilitating the identification of the factors contributing to the problem and their categorisation according to thematic similarities. The initial stage of the process is to identify the issue and delineate the boundaries of the diagram. In the second stage, the potential sub-causes of the problem are categorised and grouped under main headings [42]. In the initial phase, the diagram assumes the configuration depicted in Figure 2.

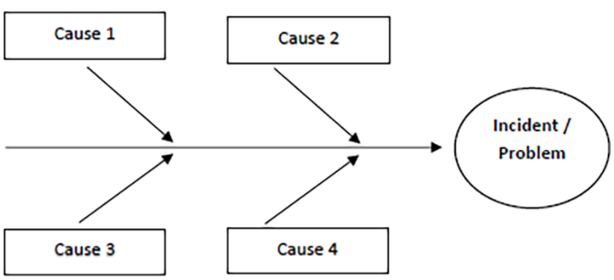

Figure 2. Fishbone diagram: identifying the problem and classifying the main causes.

In the subsequent phase, the sub-causes of the categorised primary causes are identified and each sub-cause is delineated by a distinct branch drawn on the stem of the related primary cause. In other words, for each identified cause, the question "Why?" is posed once more, thereby creating deeper levels of cause [39]. Consequently, the diagram assumes the configuration depicted in Figure 3.

In the final stage of the process, all participants in the research evaluate the sub-causes and identify the root cause of the problem [42]. The benefits of identifying the root cause by progressively deepening the research question, categorising the factors influencing the problem and visualising the established cause-and-effect networks make the fishbone diagram an effective tool for case analysis. It is anticipated that the integration of the fishbone diagram with the 5 Why technique will facilitate the identification of the root causes of accidents. Furthermore, the findings obtained will be instrumental in understanding the role of BRM on navigation safety. The findings obtained within the scope of the study were evaluated through structured interviews with six masters and three chief engineers, with the objective of determining the root and sub-causes of the accidents. The participants were selected on the basis of their expertise in interpreting accident dynamics and in providing a dual perspective from both the deck and engine, as outlined in Table 1.

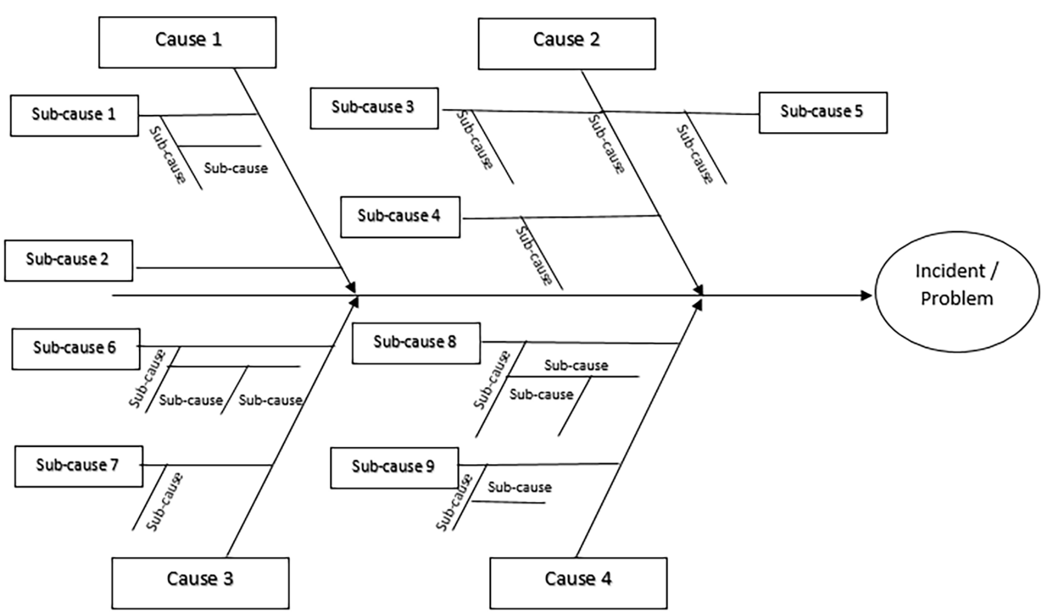

Figure 3. Fishbone diagram: identification of sub-causes.

3. Findings

In the context of the study, accident records were gathered from Republic of Türkiye Ministry of Transport and Infrastructure Transportation Safety Investigation Center [44]. These records were contained a number of sources, including ship technical information, navigational information, accident information, personnel information and environmental factor information. The findings are presented in Figure 4.

As illustrated in Figure 4, the findings are classified into five distinct categories. These are classified as follows: technical information (including full length, width, type, flag, tonnage and class); navigational information (including departure/arrival, cargo and pilot status); accident information (including accident location, time, type, fatalities/injuries and pollution information); personnel information (including number and nationality of personnel); and environmental factors (including current, wind and visibility conditions). The accident summary analysis, created in accordance with the findings obtained, is presented in Figure 5.

Table 1. Personal and professional characteristics of the participants.

Participants	Gender	Age	Professional experience	Profession
K1	Male	64	35	Oceangoing Master
K2	Male	62	31	Oceangoing Master
K3	Male	62	17	Oceangoing Master
K4	Male	57	28	Oceangoing Master
K5	Male	65	42	Oceangoing Master
K6	Male	67	43	Chief Engineer
K7	Male	42	24	Chief Engineer
K8	Male	45	21	Oceangoing Master
K9	Male	40	18	Chief Engineer

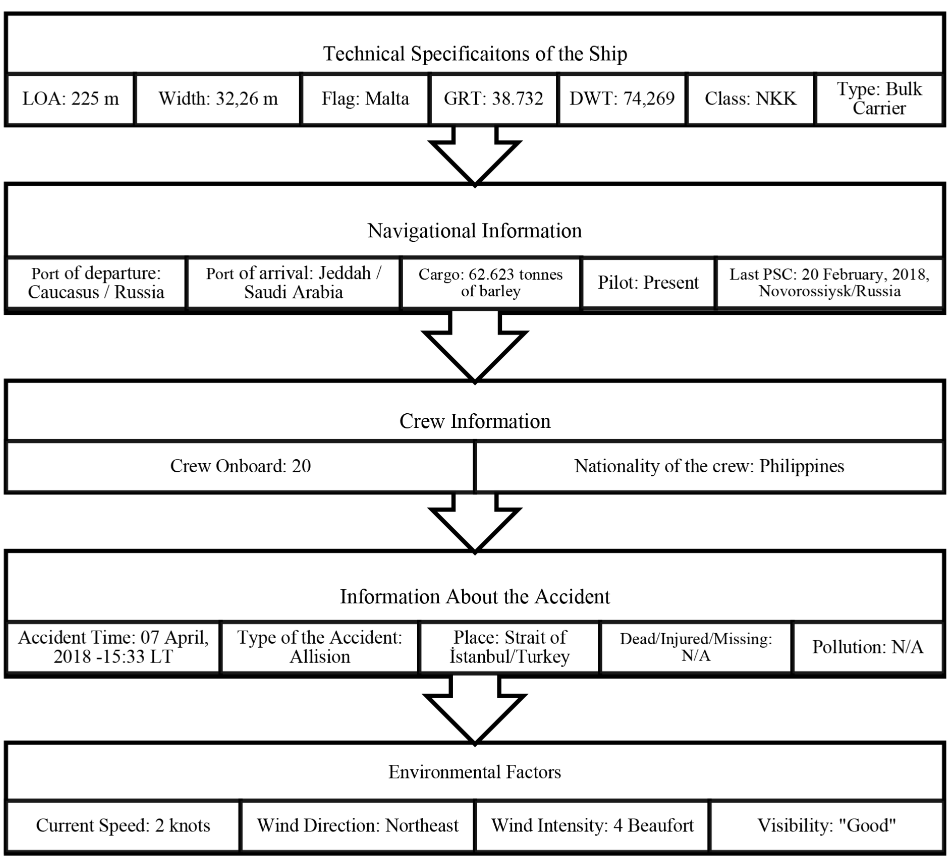

Figure 4. Classification of accident information.

The results of the 5 Why technique, which identify potential underlying causes of the MV VITASPIRIT accident in the İstanbul Strait, are presented in Figure 6.

When the accident findings evaluated by the participants were analyzed within the scope of the 5 Why technique, it was seen that the root causes of accidents were grouped under five categories. The first category is analyzed in terms of equipment maintenance and materials. According to this, the most superficial reason why the ship allided to the mansion is that no effective maneuver could be made to avoid the accident. Under the 5 Why technique, the question of why no effective maneuver could be performed is explained by the loss of the ship's steering ability. When the question of why was asked for the second time, it was found that the reason was that the main engine shutdown. The question asked about why the main engine shutdown is explained by the drop in RPM. The fourth why question indicated that the reason for the drop in RPM was the sudden loss of cooling

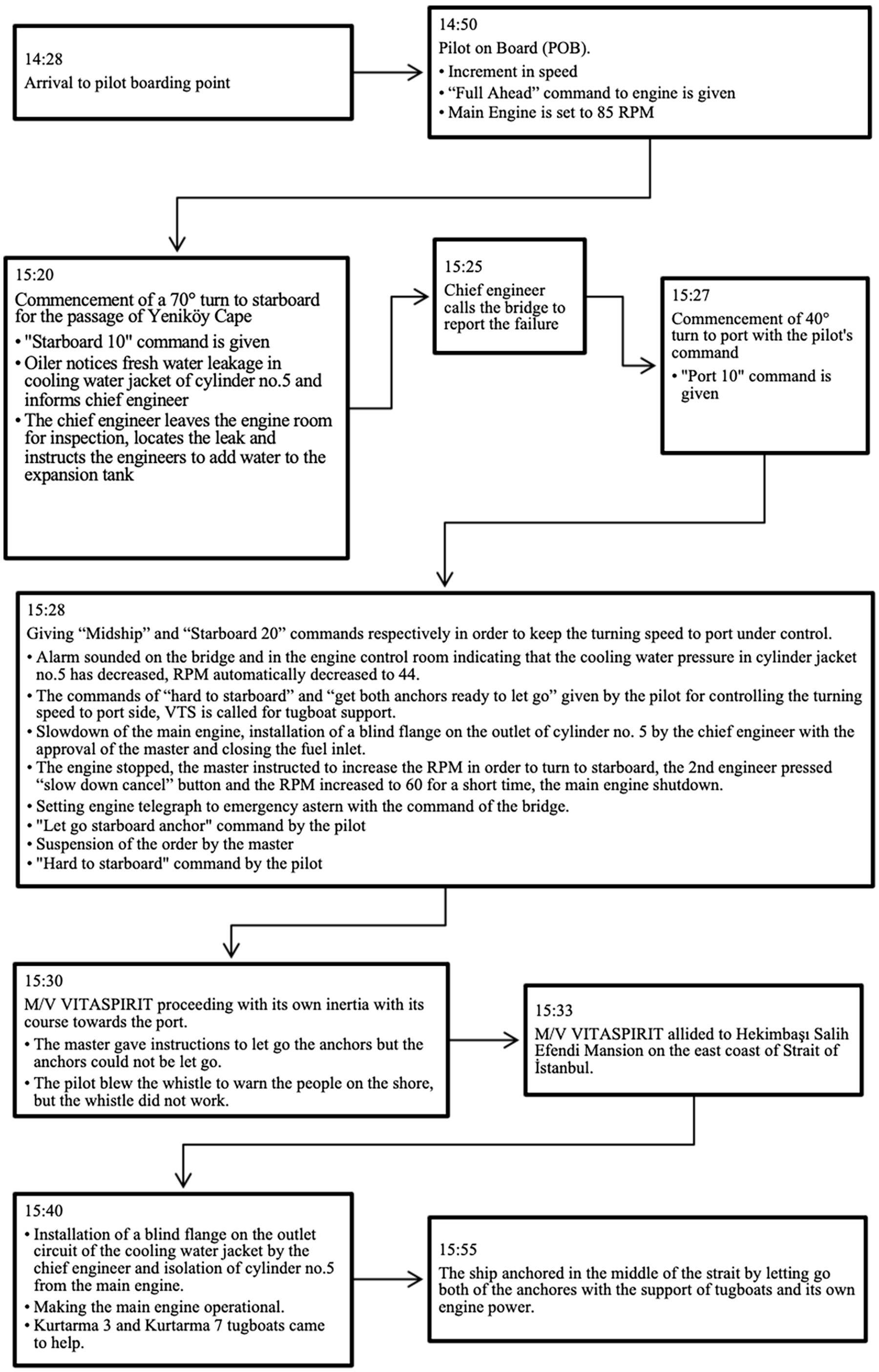

Figure 5. Accident summary review [33].

water. When the question was asked for the fifth time, it was discovered that this situation was due to a water leak in the cylinder jacket number 5. So at the end of the process of the 5 Why technique, it was concluded that one of the root causes of the accident was the material and the equipment. The corresponding process is shown in Figure 7.

It is considered that miscommunication due to inadequate English within the scope of BRM was another main factor that caused the accident. Accordingly, in the process that started with the problem at cylinder jacket number 5 and turned into an accident when the necessary action could not be taken at the right time; it is considered that one of

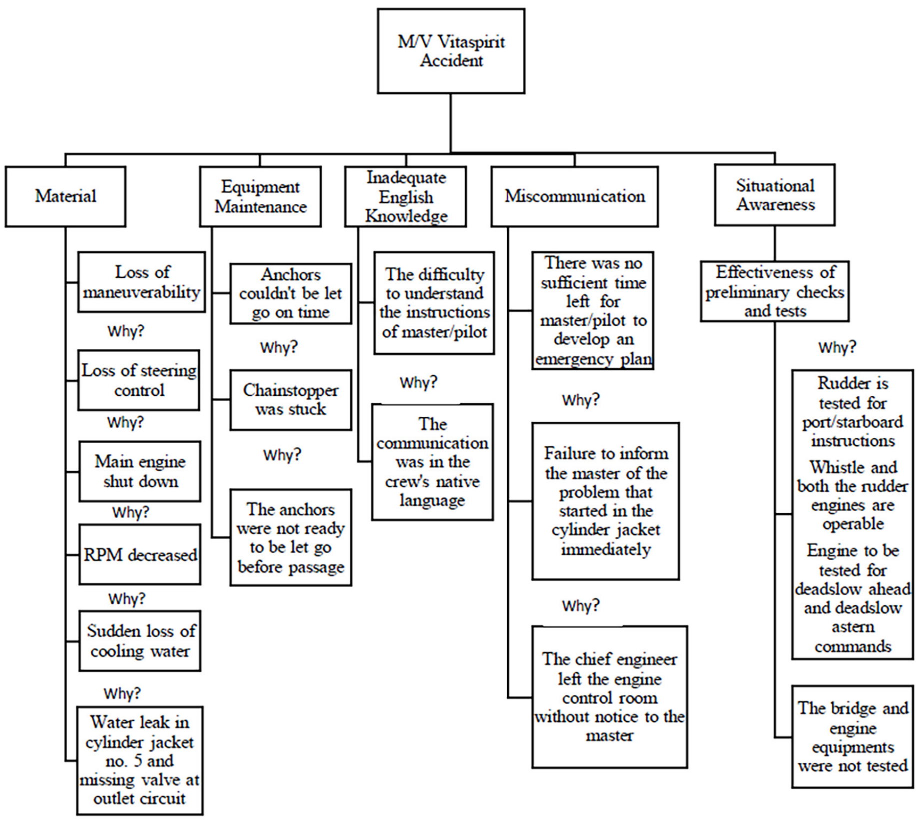

Figure 6. 5 Why technique findings for the M/V VITASPIRIT accident.

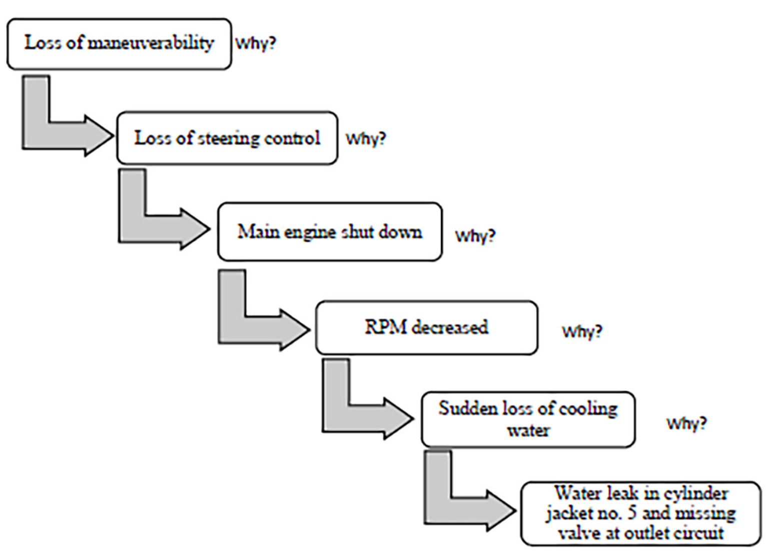

Figure 7. Identification of sub-causes: Material.

the possible main causes of the accident was the difficulty encountered by the crew in understanding the pilot's orders. The "why" question asked for this problem is explained by the fact that communication on board is mostly done in the native language of the crew. The re-asked why question leads to the conclusion that the root cause of the communication difficulty is inadequate English. The related process is shown in Figure 8 below.

Within the scope of BRM, the lack of effective management of the information source created another miscommunication between the master / pilot and master / chief engineer. It is considered that this situation changed the course of the accident by missing the opportunity to call vessel traffic service and tugboats for help earlier. The findings obtained within the scope of the 5 Why technique regarding the process are shown in Figure 9.

Situational awareness, which is the most important element of human factor within the framework of resource management, is considered to be one of the root causes of the accident. The fact that there were only 7 minutes between the reporting of the engine failure to the bridge and the accident left no time for the master/pilot to develop an emergency plan. However, according to ISM, any change in speed due to engine/rudder failures should be reported immediately to the bridge by the engineers [44]. Failure to inform the master immediately about the problem that started in the engine caused a maneuvering disagreement between the master and the pilot and did not leave time to develop an effective accident preventive strategy. It is considered that the chief engineer's leaving the engine control room to solve the problem without informing the master caused time loss. The findings obtained within the scope of 5 Why technique regarding situational awareness are given in Figure 10.

The results obtained showed that the lack of situational awareness, which is evaluated within the scope of BRM, is both a root cause in itself and a sub-cause that triggers other factors. As a result of the 5 Why technique, situational

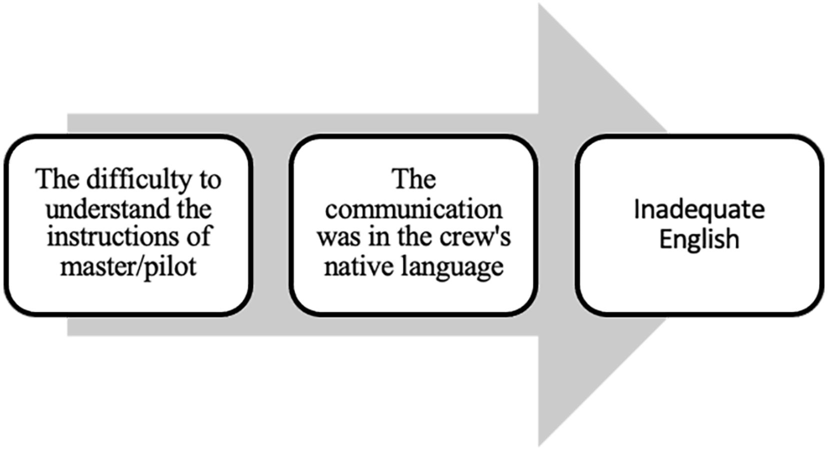

Figure 8. Identification of sub-causes: Miscommunication/insufficient English.

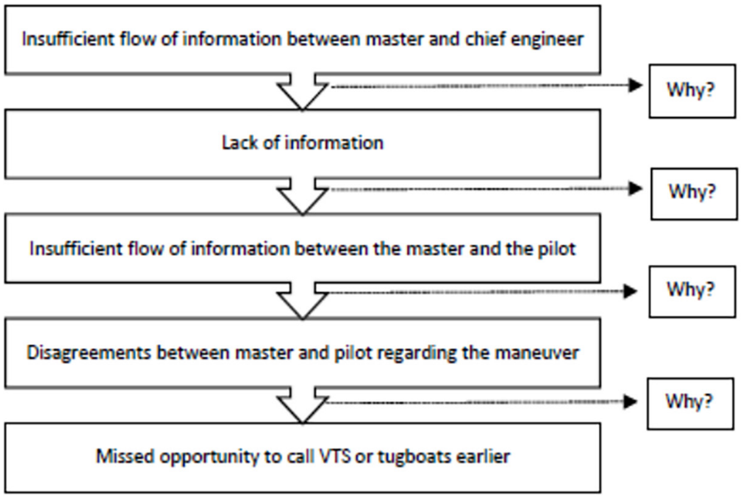

Figure 9. Identification of sub-causes: Miscommunication - lack of information flow.

awareness categorized under the human factor also plays a decisive role in material maintenance attitude and equipment testing/drills. The findings of the accident indicate that the anchors could not be let go in time because the chainstopper could not be moved after the "let go" command. This situation draws attention to the lack of preparation and reveals the importance of adopting routine checks and preparations on board as a safety culture rather than a procedure. The results obtained within the scope of the 5 Why technique formed the main categories of the fishbone diagram. Within the scope of the study, the root causes of the accident were categorized within the framework of "Management (BRM), Equipment, Material, Human and Communication" and the results of the fishbone diagram integrated with the 5 Cause Technique are given in Figure 11.

Within the scope of the fishbone diagram, the root and sub-causes of the accident were determined as follows.

Management: Ineffective management of human, information and equipment resources. It is thought that the following vulnerabilities observed during the preliminary controls of the bridge and engine equipments weakened the safety of navigation and paved the way for the accident.

- Preliminary check of rudder's responsiveness with hard to port/starboard commands.
- Preliminary check that the dual rudder engines are operational.
- Testing the main engine including deadslow ahead and deadslow astern commands.
- Not keeping both anchors ready to let go before the strait passage.
- Preliminary check that the whistle is operational.

Equipment: Due to the water leakage that started in cylinder jacket number 5, the engine power and speed decreased, resulting in the shutdown of the main engine. This situation has weakened the steering ability of the ship and eliminated the maneuvering capability.

Material: Age, material and equipment were considered to be the determining factors in terms of performance on

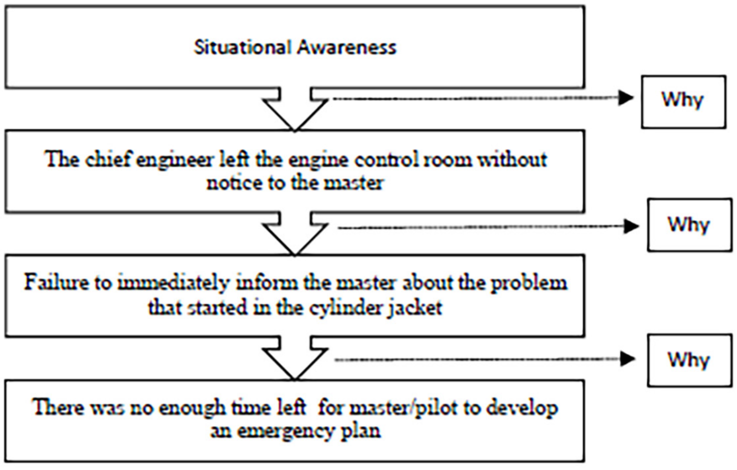

Figure 10. Identifying sub-causes: Situational awareness.

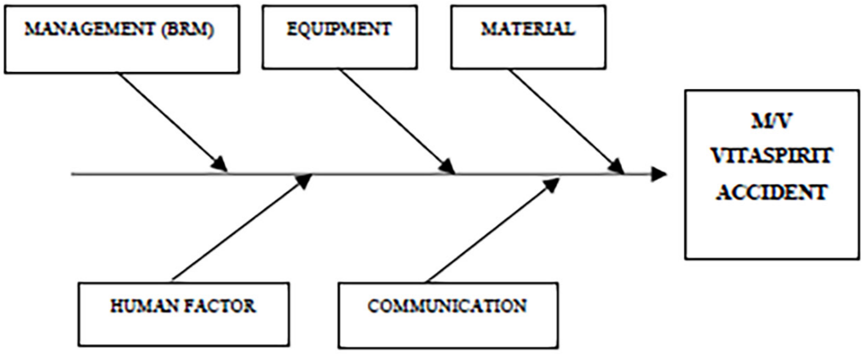

Figure 11. Fishbone diagram classification of main causes.

the ship, which was the subject of the accident. The water leak in the cylinder jacket, the inability to release the chain stopper running over the anchor chain as commanded let go and consequently the inability to let go the anchors in time to counter the forward motion of the ship, as well as the observation that the ship's whistle did not work when instructed, indicate the lack of maintenance and preparation of the ship's components/parts.

Human Factor: The results of the research draw attention to the fact that the human factor is determinant on the accident, especially within the framework of situational awareness. In this respect, the chief engineer's leaving the engine control room without informing the master in order to intervene in the water leakage that took place in the number 5-cylinder jacket is considered to be one of the critical factors affecting the course of the accident. This situation caused the master to be unaware of the need to isolate the leaking cylinder and revealed the lack of preparedness for emergency situations on the bridge. The time loss in this process also left no time for the master and pilot to develop an emergency plan.

Communication: The results obtained within the scope of the study support the conclusion that the lack of effective communication between the master and the chief engineer and between the master and the pilot were the factors that paved the way for the accident. The chief engineer's failure to provide immediate information resulted in the master not being aware that the propulsion power might be lost or that he would have to stop the engine to isolate the damaged cylinder jacket [44]. This situation also triggered a disagreement about maneuver between the master and the pilot. However, it was found that inadequate English was a critical factor in the accident. Although the working language onboard was English, the fact that the vessel's crew communicated in their native language made it difficult for the pilot to follow the engine-related conversations and for the crew to understand and implement the emergency instructions given by the pilot in a timely manner. The fishbone diagram formed according to the findings is shown in Figure 12.

4. Discussion

Within the scope of the RCA conducted regarding the M/V VITASPIRIT accident, it was observed that the root causes of the accident were the building blocks within the BRM. The results of the study showed that the failure to manage human, information and equipment resources correctly and effectively could be the possible main causes of the accident and drew attention the importance of the preliminary preparations needed to be carried out and controls within the scope of BRM. At this point, it has been observed that communication and awareness, which separate the human factor from the technical elements, are the main dynamics affecting the accident process. Also, the findings of the accident point to the critical importance of equipment-based maintenance activities. The fact that a small problem in the cylinder jacket can pave the way to a major accident has drawn attention to the importance of daily checks carried out

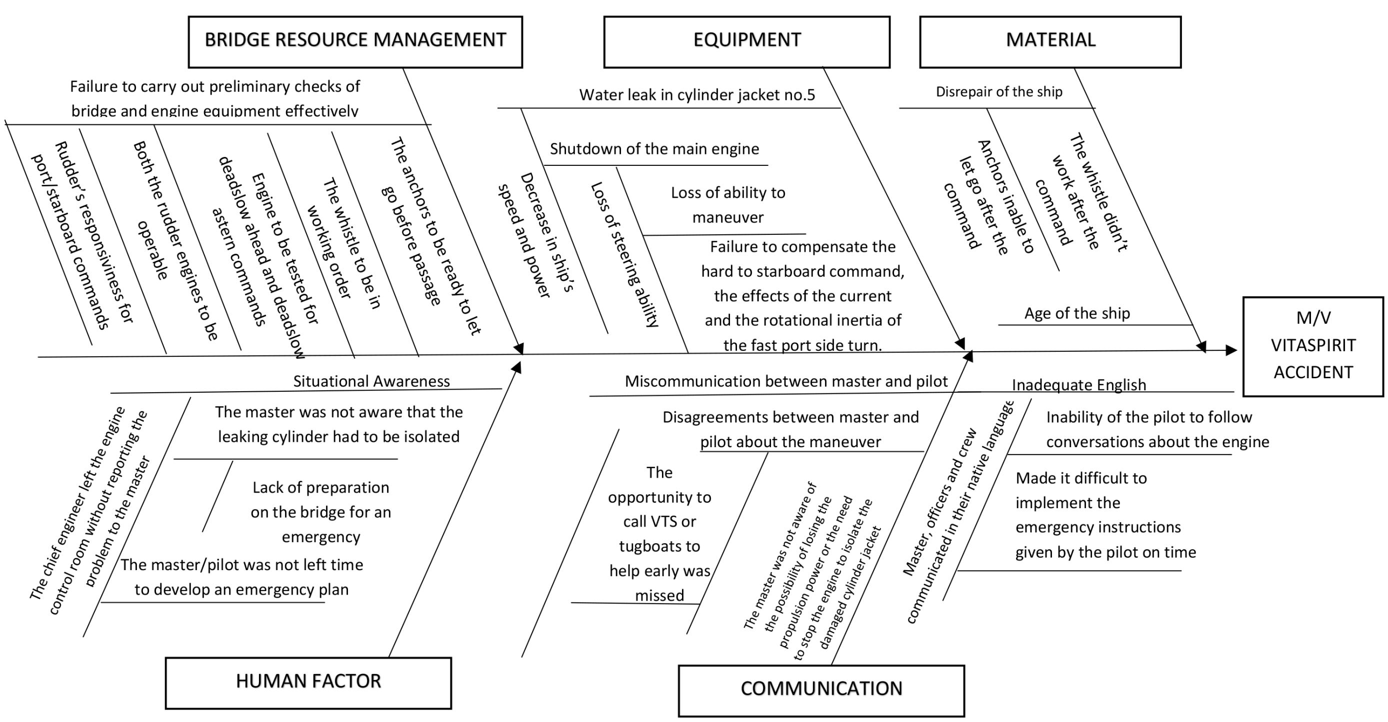

Figure 12. Fishbone Diagram of the root causes of the M/V VITASPIRIT accident.

with situational awareness apart from the inspection period. In this respect, one of the biggest advantages of BRM has emerged as that it creates awareness for equipment-based controls in relevant areas and transforms self-inspection into a safety culture. At this point, the results of the study confirmed the hypothesis that efficient resource management is an effective tool to prevent accidents and that BRM needs to be strengthened to improve safety of navigation.

5. Conclusions

This research is a case study on the M/V VITASPIRIT accident in order to observe the impact of BRM on navigational safety. The in-depth analysis of this accident has provided concrete outputs to the literature on BRM. It is important to examine accidents with similar profiles in order to verify, strengthen and generalize the results obtained in this accident. The common findings obtained by analyzing different accidents will serve as a reference for updating the existing legal practices and regulations within the scope of BRM in a way to increase the safety of navigation. At this point, it is suggested that future studies should carry the research further and produce a road map for policy makers in line with the common findings.

Footnotes

Authorship Contributions

Concept/Design: G. Kodak, Data Collection or Processing: G. Kodak, Analysis or Interpretation: G. Kodak, Literature Review: G. Kodak, and A. Dal., Writing, Reviewing and Editing: G. Kodak, and A. Dal.

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