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Comprehensive Studies On Hydrocarbon Transport Emergency Preparedness In Perspective of Statutory Requirement And Industrial Guidelines

1st Dina Kristina Tanjung
Universitas Kristen Indonesia
Jakarta, Indonesia
dinakristina@gmail.com

2nd Aleik Nurwahyudy
National Transportation
Safety Committee
aleiknurwahyudy@gmail.com

Abstract—**This study examines emergency preparedness for hydrocarbon transport operators from the perspective of industrial guidelines and statutory requirements, focusing on the Tanker Management and Self-Assessment (TMSA) and International Safety Management (ISM) codes. The growing global demand for hydrocarbons has expanded the fleet servicing the sector, but an increasing number of incidents has accompanied this growth. Utilising a semi-qualitative approach, the study conducted direct surveys with shipping management to assess their readiness to handle emergencies. The findings reveal a significant gap between company policy and shipboard implementation. Key issues include inadequate response team support, poorly conducted emergency drills, and a lack of coordination between shore-based management and shipboard crew, which hinder effective emergency management. The study highlights improved training, communication, and alignment between operational practices and policy to ensure better preparedness and incident mitigation.**

Keywords—TMSA, Emergency Preparedness, ISM Code, Hydrocarbon Transport

I. Introduction

Hydrocarbon transport is the backbone of global energy distribution, connecting resource-rich regions with energy-hungry markets worldwide. [1] [2], [3]. As the world's primary energy source, hydrocarbons—mainly oil, natural gas, and coal—are essential to fueling industries, transportation, and even everyday household energy needs. The demand for hydrocarbons has grown exponentially due to rapid industrialisation, urbanisation, and population growth, especially in emerging economies such as China, India, and parts of Africa [4]. This has spurred the continuous expansion of hydrocarbon extraction, refining, and, crucially, transport systems to ensure a steady supply to markets thousands of miles away from production centres [2].

The worldwide demand for hydrocarbons has profoundly impacted the supply chain, particularly the maritime transport sector. The global fleet of tankers, liquefied natural gas (LNG) carriers, and bulk carriers has expanded significantly to meet this demand. Unlike other commodities, hydrocarbons require specialised transportation methods to ensure safety, given their volatile and hazardous nature. [1], [5], [6]. These fleets now traverse vast distances across oceans, from the oil fields of the Middle East, the shale reserves of North America, and the natural gas basins in Russia to the refineries and energy markets in Asia, Europe, and beyond. [7].

The growth of this fleet mirrors the geographic spread of hydrocarbon sources. While historically dominated by a few major exporters such as Saudi Arabia, Russia, and the United States, new exploration and production zones have emerged, expanding the global hydrocarbon supply network. Countries in West Africa, Latin America, and Southeast Asia have become important players, diversifying the worldwide supply and further stretching the distances hydrocarbons travel from production to consumption points. [2], [8].

As the volume of hydrocarbons transported rises, so does the complexity of the logistics involve. Modern fleets must meet the demand and adhere to strict international regulations governing safety, environmental protection, and efficiency. [1]. With routes growing longer, the risk of accidents or spills has increased, prompting more rigorous standards for fleet operations and emergency preparedness. As a result, transport companies must now invest heavily in safety protocols, technological upgrades, and training to mitigate the risks associated with long-distance hydrocarbon transportation. [9], [10]Furthermore, the increase in the global fleet also reflects the diversity of hydrocarbon products being shipped. Crude oil, refined petroleum products, natural gas, and chemicals require different vessel types, storage, and handling methods. [2]. The growth in demand for natural gas, for example, has driven the expansion of the LNG fleet. At the same time, advancements in shipping technology have allowed for more extensive and more efficient tankers that can carry more significant quantities of hydrocarbons over longer distances. [1].

Hydrocarbon transport is vital to the global energy supply chain and one of the most vulnerable sectors to potential disruptions [11]. The intricate network of shipping routes that connect hydrocarbon-producing regions to international markets spans thousands of miles across oceans, where geopolitical tensions, environmental hazards, and operational risks frequently pose challenges [8]. Disruptions in the hydrocarbon supply chain can have significant ripple effects, causing energy shortages, price volatility, and economic instability, as these resources are essential to powering industries, transportation, and households globally [5], [9]. Several key factors can disrupt hydrocarbon transport, including war, piracy, accidents, and operational incidents. Wars and geopolitical conflicts can severely disrupt hydrocarbon transport routes. Many of the world's critical hydrocarbon-producing regions, such as the Middle East, North Africa, and Eastern Europe, are often at the centre of geopolitical tensions [8]. For example, the Strait of Hormuz, where approximately 20% of the world's petroleum passes, is highly vulnerable to disruption due to military conflict or political standoffs [12]. Similarly, the ongoing conflict between Russia and Ukraine has already caused significant disruptions in the global oil and natural gas supply, leading to the redirection of cargo, the imposition of sanctions, and the volatility of energy markets. Conflicts can also destroy infrastructure such as pipelines, storage facilities, and ports, further complicating the distribution process. War zones or conflict-prone regions increase the risk for hydrocarbon vessels navigating these waters, sometimes forcing ships to take longer, less efficient routes, which increases costs and delivery times [13], [14]. In extreme cases, blockades or military interventions can halt hydrocarbon exports, leading to critical shortages in importing countries. Piracy remains a significant threat to hydrocarbon transport, particularly in specific regions like the Gulf of Guinea, the Strait of Malacca, and the Somali coast [15]. Piracy not only endangers the safety of crew members but also the security of valuable cargo such as crude oil, liquefied natural gas (LNG), and refined petroleum products. In some cases, pirates hijack vessels, demanding ransom or siphoning off portions of the cargo, which leads to both financial losses and delays in delivery schedules. The economic impact of piracy extends beyond direct losses. Shipping companies often have to divert vessels from high-risk areas to mitigate risks, increasing voyage distances and costs. Additionally, insurance premiums rise for ships travelling through pirate-infested waters, further inflating the price of hydrocarbon transportation. Naval escorts, private security, and additional countermeasures are also needed to safeguard vessels, adding another layer of cost and complexity to the supply chain [16].

Accidents and incidents at sea are another significant source of disruption in hydrocarbon transport. Oil spills, collisions, and explosions can have catastrophic consequences, both environmentally and economically. [11], [17], [18]. Accidents involving large tankers carrying crude oil or LNG can lead to massive oil spills, devastating marine ecosystems, and incurring hefty cleanup costs. [18]. These incidents often lead to the temporary suspension of transport services in the affected area as authorities respond to the environmental emergency, further delaying hydrocarbon shipments. For instance, high-profile incidents like the Exxon Valdez spill or the Deepwater Horizon explosion have caused ecological disasters, sparked regulatory changes, increased operational costs for companies, and tightened the safety requirements for fleets transporting hydrocarbons. In addition, accidents can also occur during the loading or unloading of hydrocarbons at ports and terminals, causing fires, explosions, or contamination that interrupts the supply chain at critical nodes. [14]. Operational incidents, often stemming from human error, technical failures, or inadequate emergency preparedness, frequently disrupt hydrocarbon transport. [19].

Despite stringent regulations like the International Safety Management (ISM) code and the Tanker Management and Self-Assessment (TMSA), gaps between company policies and onboard implementation can lead to mishandling critical situations. [20], [21]. Improper emergency drills, lack of coordination between shipboard crews and shore-based management, or inadequate response teams can exacerbate the impact of incidents, transforming minor operational errors into significant disruptions. [9], [22], [23]. For instance, a failure to properly manage maintenance or equipment issues can lead to breakdowns or mechanical failures during long voyages, forcing ships to divert for repairs or causing delays in delivering hydrocarbons. Such delays can lead to contractual penalties, increased fuel costs, and disruption of supply agreements, particularly in tightly regulated and competitive energy markets. [24].

Extreme weather events such as hurricanes, typhoons, or severe storms can also disrupt hydrocarbon transport by delaying voyages, damaging vessels, or preventing the safe docking of tankers. Natural disasters such as earthquakes or tsunamis may destroy critical infrastructure like ports, refineries, or pipelines, halting the flow of hydrocarbons entirely in affected regions. For example, the Gulf of Mexico, a critical U.S. oil and gas production region, is frequently impacted by hurricanes that forced the temporary shutdown of offshore oil rigs and transport routes, leading to supply chain bottlenecks. [3], [25].

Regulatory changes can also disrupt hydrocarbon transport. As concerns over climate change and environmental protection intensify, governments impose stricter emissions regulations, safety protocols, and environmental standards on shipping companies. [21]. While these regulations are essential for reducing the environmental impact of hydrocarbon transport, they can cause temporary disruptions as companies adapt to new rules. These may include fuel type restrictions, slower fuel efficiency speeds, and installing costly emissions control technology. [26], [27].

The data on accidents involving hydrocarbon transport in bulk in Indonesia from 2007 to 2023 reveals critical trends in the frequency and types of incidents. Each year is categorised based on different accidents, such as explosions, fires, capsizes, collisions, sinking, grounding, etc. [28]. By analysing this data, the research obtains insights into the overall safety performance of hydrocarbon transport and identifies areas for improvement.

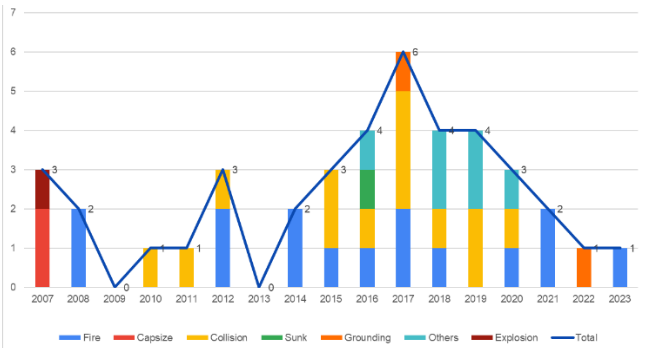

Fig. 1. Hydrocarbon transport in bulk accident/incident data 2007 – 2023. Data extracted from KNKT database.

From 2007 to 2023, the total number of incidents varies, with notable peaks in specific years. 2017 stands out with the highest reported incidents (6), followed by 2016, 2019, and 2020, which also had relatively high numbers. However, a gradual decline is observed in the later years, particularly after 2020, where incidents dropped to one per year in 2022 and 2023. This decrease may suggest that safety measures in hydrocarbon transport have improved over time, although specific incidents remain persistent. Explosions occurred only once in 2007 and did not reappear in subsequent years. This positive indicator suggests that although extremely hazardous, explosions are rare in the industry and may be well-controlled through proper procedures and risk management. On the other hand, fires were more frequent and occurred sporadically throughout the data set. Fires were particularly prevalent in 2008, 2012, 2015-2017, and 2021, with notable peaks. This indicates that fire safety remains a key challenge in hydrocarbon transport, possibly due to the flammable nature of the cargo and operational risks onboard vessels. Continuous monitoring and improvement in fire prevention systems and crew readiness are essential to reduce the risk of fire-related accidents.

Capsize incidents were reported only in 2007, with no further occurrences afterwards. Structural improvements, better training, or improved weather forecasting have contributed to eliminating capsizing risks in later years. Collisions showed a concerning trend, with incidents occurring more frequently between 2010 and 2020. The number of collisions spiked particularly in 2017 (with three incidents), highlighting the need for enhanced maritime safety measures. Collisions are a significant concern in busy shipping lanes, particularly where domestic and international routes overlap. Better training for crew, improved radar and communication systems, and stricter adherence to navigational protocols may help reduce these types of accidents. Sinking incidents were rare, with only one occurrence in 2016. Although infrequent, the severity of sinking incidents should not be overlooked, as they pose significant risks to human lives and environmental safety. Grounding incidents were similarly infrequent, with only two occurrences, one each in 2017 and 2022. Grounding can often result from navigational errors or poor weather conditions, indicating that vigilance is still required, while this is not a recurring issue.

The Other category includes critical incidents that must fall neatly into the predefined classifications. There was a noticeable rise in these incidents between 2016 and 2020, with multiple incidents reported in specific years. This category indicates the complexity of risks associated with hydrocarbon transport, including operational mishaps, equipment failures, or other unforeseen circumstances. The overall trend shows that hydrocarbon transport incidents peaked in 2017 and gradually decreased in the years following. The notable reduction in incidents post-2020 suggests that improvements in safety regulations, better vessel designs, crew training, and compliance with international safety standards have positively impacted reducing accidents. However, the recurrence of specific incidents, particularly fires and collisions, highlights persistent vulnerabilities. Fires remain a significant challenge, especially given the volatile nature of hydrocarbons, while collisions emphasise the importance of robust navigational protocols in congested waters. Additionally, the infrequent but severe nature of incidents like sinking and grounding demands attention, as these accidents pose risks to human lives and the environment due to potential oil spills or cargo loss. [10].

The data highlights both progress and ongoing challenges in ensuring the safety of hydrocarbon transport in Indonesia. While the reduction in overall incidents in recent years is promising, the industry must continue to focus on high-risk areas such as fire safety and collision prevention [29], [30]. Improvements in emergency preparedness, vessel maintenance, and crew training are essential to sustain and further this positive trend.

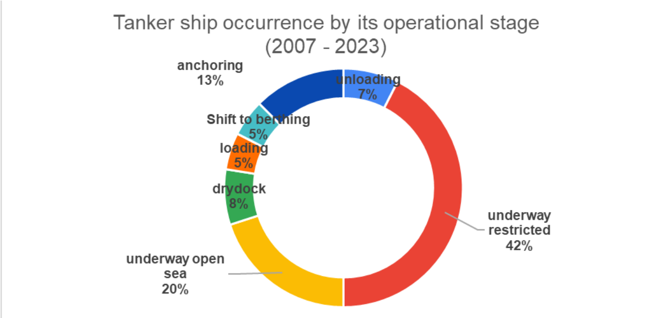

Fig. 2. Accident/incident data involving hydrocarbon transport ships based on the stage of ship operation.

The chart illustrates the distribution of hydrocarbon-related accidents involving tanker ships from 2007 to 2023 based on the operational stage during which they occurred. Each section of the ring chart represents a different tanker operation phase, showing the accident frequency in each stage. The data underscores that the most hazardous operational stage for hydrocarbon-carrying tankers is during underway restricted conditions, followed by open sea navigation and anchoring. Proper navigational protocols, crew training, and vessel maintenance are essential in these stages. Loading and unloading, while accounting for a smaller proportion of incidents, still carries high risks, given the nature of the cargo. The presence of accidents during drydocks and anchoring also emphasises that safety measures must be maintained even when the tanker is not actively transporting hydrocarbons.

The most significant portion of accidents, accounting for 42%, occurred when tankers were underway but under restricted conditions. This suggests navigating through congested, narrow, or otherwise challenging waters presents significant risks. Limited manoeuvrability and complex environmental factors, such as shallow waters or poor visibility, could contribute to the high accident rate during this phase. Following this, 20% of the accidents happened while the tankers were underway in open sea conditions. Although open sea operations generally allow for more space and flexibility, risks remain due to potential mechanical failures, adverse weather conditions, or human error. The relatively high number of accidents at sea highlights the importance of ongoing vigilance and proper maintenance, even in open waters. Accidents during the anchoring phase made up 13% of the incidents. This phase poses risks from improper anchoring techniques, sudden environmental changes like strong winds or currents, and operational errors during the anchor deployment or retrieval. While anchoring might seem less risky, the data shows it requires careful attention. Interestingly, 8% of the accidents occurred while tankers were in drydock, typically involving maintenance and repair work. Accidents during this stage might be attributed to the hazards associated with complex repair operations, human error, or failure to follow safety protocols during maintenance tasks. The unloading stage, responsible for 7% of accidents, highlights the risks of handling volatile hydrocarbons. Failures in equipment, breaches in safety measures, or human error during cargo transfer could lead to fires, spills, or explosions. Similarly, 5% of accidents occurred during loading, a stage with similar risks, where missteps can result in dangerous incidents. Finally, 5% of accidents occurred while the tanker shifted to berthing or docking. This critical phase requires precision, and accidents could occur due to poor coordination, miscalculations, or harsh environmental factors leading to collisions or groundings.

Emergency response systems are crucial for managing risks of maritime and oil/gas operations, particularly in challenging environments like Arctic waters. Chircop et al. (2020) imply that these systems aim to protect lives, property, and the environment. [31]. For oil spills from ships, a quantitative decision-making model has been developed to aid in selecting the best response action, considering factors such as spill volume and distance to fairways following research by Wu et al. (2020) [32]. Habibah et al. (2022) stated in oil and gas companies, comprehensive fire emergency response systems are implemented, including active protection (e.g., extinguishers, hydrants) and passive protection (e.g., evacuation routes, muster points) measures. Additionally, these companies form fire-fighting teams, conduct training and simulations, and establish standard operating procedures. [10]. Santner et al. (2022) identified that oil spill preparedness and response are critical for mitigating the environmental and economic impacts of marine pollution accidents. Studies have shown that effective preparedness significantly influences successful emergency responses to ship pollution incidents. [33]. Che Ishak et al. implied that critical factors in preparedness include assets, human error prevention, and response planning. [34]. Santner and Cramer (2021) present that over the past decade, the oil and gas industry has substantially invested in improving oil spill preparedness and response capabilities. Initiatives like the Oil Spill Response Joint Industry Project (OSR-JIP) and the American Petroleum Institute's Joint Industry Task Force (API-JITF) have produced numerous technical reports and best practices. [33]. These efforts have led to advancements in spill impact mitigation assessment, incident management, and dispersant use. Research has also enhanced understanding of response option efficacy and environmental effects. Ongoing industry programs continue to build on these developments, emphasising the importance of continuous improvement in oil spill preparedness and response strategies.

Since the early 2000s, the safety management code has been widely acknowledged as a crucial instrument for improving maritime transport safety. [35], [36]. Despite its critics, the application of the code is so dynamic. IMO, recent publications on the effectiveness of the code indicated good progress but more stagnation. ISM cover a wide range of aspects, which are mostly related to how the shipping company should establish a system to ensure their fleet safety [37]. Related to the research objective, ISM Code Element 8 on emergency preparedness ensures that shipping companies and their vessels are fully prepared to respond effectively to emergencies at sea. This element outlines the framework companies must follow to identify potential emergencies, establish response procedures, conduct regular drills, and ensure constant readiness to manage hazards, accidents, and emergencies. The critical aim of Element 8 is to minimise the impact of emergencies on human life and the environment while maintaining the integrity of the vessel. Element 8 mandates that companies identify potential emergencies onboard their vessels. These situations could include but are not limited to Fires and explosions, Collisions or groundings, Oil spills or hazardous material leaks, Man overboard scenarios, Machinery failures, piracy or armed attacks, Severe weather conditions, Cargo-related incidents, such as leaks or spills from dangerous goods. [37].

A company's safety management system (SMS) must include a comprehensive risk assessment that identifies all foreseeable emergencies based on the type of cargo, the vessel's operational areas, and historical data from similar operations. The policy should ensure that shore-based management and the vessel's crew know the specific emergency scenarios they may face. For example, a company transporting hydrocarbons should have specific procedures to deal with oil spills, as the potential risk is high. [23], [38].

ISM Code Element 8 requires companies to develop a robust emergency preparedness framework that identifies potential emergencies, establishes clear response procedures, mandates regular drills, and ensures constant readiness. The correlation with company policy is crucial because the policies must reflect the practical implementation of these requirements across the company's fleet. [39]. Well-drafted company policies ensure crews have the knowledge, skills, and tools to manage emergencies, thereby protecting lives, reducing environmental impact, and minimising financial losses. [40]. A proactive approach to emergency preparedness strengthens the company's safety culture, leading to fewer incidents and better compliance with international regulations.

OCIMF developed TMSA (Tanker Management and Self-Assessment) [41]. Relevant to emergency preparedness, TMSA Element 11 focuses on Emergency Preparedness and Contingency Planning. The element is critical in ensuring that ship management companies, particularly those involved in oil and gas transportation, are adequately prepared to respond to emergencies. The element outlines a progression of stages that reflect increasing levels of sophistication and maturity in a company's approach to managing crises, from essential compliance to industry leadership. [20].

In Stage 1, the focus is primarily on meeting basic compliance requirements. Companies at this level ensure that they have fundamental emergency response plans in place, covering critical scenarios such as fires, spills, and evacuations. The emphasis is on having the minimum requirements for crew and shore personnel to follow in an emergency. Emergency drills are conducted onboard to familiarise the crew with these basic procedures. However, these plans are often reactive, addressing immediate emergencies without a comprehensive long-term prevention or continuous improvement system. The goal at this stage is to ensure compliance with regulations, but there needs to be more integration between the vessel and shore-based teams. [20].

As companies move to Stage 2, they develop more structured emergency response systems. This involves expanding emergency procedures to cover a broader range of potential crises, including more complex collisions, piracy, and oil spills. There is an increased emphasis on coordination between ships and shore offices, with both parties participating in regular drills. Companies also implement more formal communication protocols, ensuring clear lines of communication between vessels, shore-based teams, and external authorities. This stage marks a shift towards proactive planning, where companies start to anticipate potential risks and work to mitigate them. Crisis management teams are more formally established, and post-incident reviews have become standard practice in identifying areas for improvement.

At Stage 3, companies have a comprehensive and well-coordinated emergency response system. Crisis management procedures are fully integrated across the organisation, involving vessel and shore personnel in advanced training and regular, realistic drills. At this stage, companies respond to emergencies and focus heavily on preventive measures to avoid crises altogether. They engage in joint exercises with external stakeholders, including coastal authorities and oil spill response organisations, to ensure smooth collaboration during emergencies. There is also a strong focus on media management during crises, ensuring accurate information is communicated to the public and stakeholders. Companies at this level conduct thorough post-incident analyses and continually update their emergency response systems based on lessons learned.

Finally, at Stage 4, companies are seen as industry leaders in emergency preparedness. They go beyond industry standards, often setting new benchmarks for best practices. Companies at this level are heavily invested in continuous improvement, regularly updating their emergency procedures based on evolving risks, technological advancements, and feedback from past experiences. They adopt cutting-edge technology to enhance emergency detection and response capabilities, such as real-time communication systems, satellite tracking, and remote monitoring tools. Senior management actively supports crisis preparedness, ensuring the organisation is always ready to respond effectively. Companies at this stage are also involved in industry collaboration, working with regulatory bodies and other stakeholders to push the boundaries of emergency management and drive innovations that benefit the entire industry.

TMSA Element 11 highlights a progression from essential emergency response and compliance at Stage 1, through structured and coordinated systems at Stage 2, to comprehensive, proactive management at Stage 3, and ultimately, industry leadership and continuous improvement at Stage 4. As companies advance through the stages, they develop more robust systems, improve coordination between ship and shore, adopt advanced technologies, and focus on preventing emergencies as much as managing them. The transition through these stages reflects a company's increasing commitment to safety, risk mitigation, and crisis management excellence, essential in the high-risk environment of oil and gas transportation.

II. METHODOLOGY

The research's main objective is to review the current perception of ship management companies involving bulk hydrocarbon transhipment. From the risk inheritance of the transport model, it is deemed necessary to identify the present condition of policy within the company and their preparedness in handling emergency conditions. The research output can be used as a reference to improve the current condition and provide awareness to every stakeholder related to hydrocarbon transport. The research focuses on the perspective of Indonesian ship management companies in setting up emergency preparedness. Two primary references to evaluate such conditions are the International Code on Safety Management (ISM Code) as issued by the International Maritime Organisation (IMO) and the Tanker Self Management and Assessment (TMSA) as prepared by the OCIMF.

This paper is structured into five parts. The first chapter focuses on the introduction and brief literature review on the importance of emergency preparedness from the perspective of hydrocarbon transhipment. The second chapter presents the methodology used in this research while highlighting the development of the research questionnaire. The third chapter describes the research outcome by presenting the evaluation result, followed by a comprehensive discussion in the fourth chapter. Chapter five includes an overview of the research results, highlighting areas for improving emergency preparedness.

A. *Study flow*

Following the above description for the research objective, the research focuses on identifying a company perspective relevant to emergency preparedness. From this point, the study develops a questionnaire structure based on the ISM Code and TMSA requirements. The research contacted 24 shipping companies with various fleet sizes and trading patterns. The survey was conducted in direct interviews with manager-level officials.

B. *Questionnaires Structure*

Following each statutory and industrial requirement under OCIMF guidelines, the research develops a new model questionnaire. Figure 3 presents the correlation between the ISM code and TMSA requirements for emergency response.

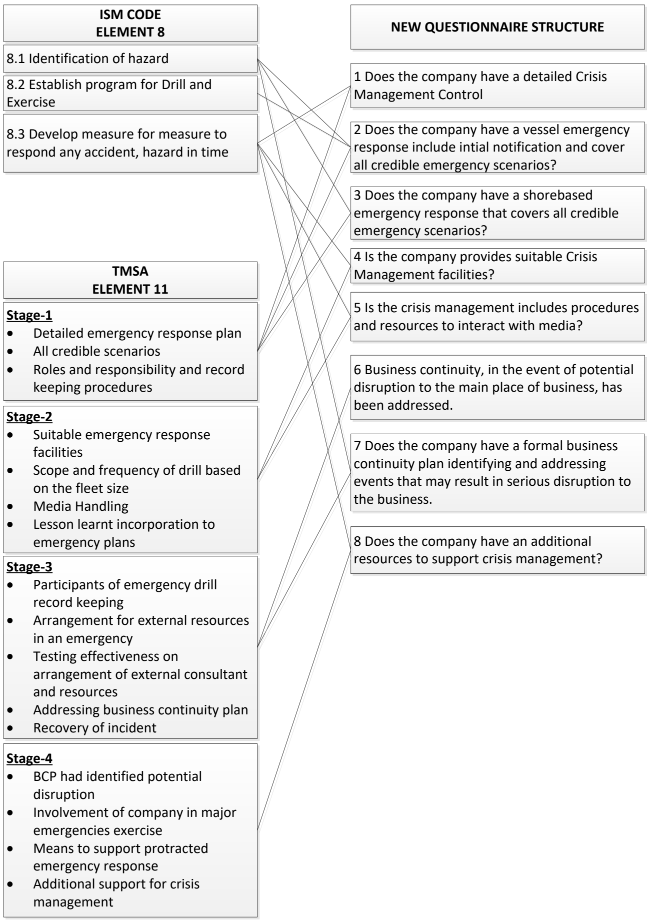

Fig. 3. Structure of questionnaire about ISM Code and TMSA requirements for emergency preparedness

TABLE 1 SET OF QUESTIONS FOR EVALUATION OF EMERGENCY PREPAREDNESS

No	Question
Q1	Does the company have a detailed Crisis Management Control System, including initial notification procedures, that covers all credible emergency scenarios?
Q2	Does the company have a vessel emergency response that includes initial notification and covers all credible emergency scenarios?
Q3	Does the company have a shore-based emergency response that covers all credible emergency scenarios?
Q4	Does the company provide suitable Crisis Management facilities?
Q5	Does crisis management include procedures and resources to interact with media?
Q6	Business continuity has been addressed in the event of potential disruption to the principal place of business.
Q7	Does the company have a formal business continuity plan that identifies and addresses events that may result in severe disruption to the business?
Q8	Does the company have additional resources to support c? Crisis management?

C. Assessments and Scoring model

Each of the criteria was assessed and presented using a scoring index. This mainly provides a quantitative view of the response. The score provided for each questionnaire is the surveyor's subject matter expertise. The surveyor views every participant's response during the interview and any evidence provided to the survey team. The score provided for each aspect within the questionnaire is the surveyor's subject matter expertise.

For this purpose, the Likert scale model was adopted. A scale of 0 (one) to 10 (ten) was used for the participants' responses and evidence. A score of 0 (zero) describes the participants' worst condition or response, whereas a score of 10 (ten) is considered an outstanding and excellent quality of response.

TABLE 2. SCORING MODEL FOR EMERGENCY PREPAREDNESS EVALUATION

Evalu-ation	Cond-ition	Evalu-ation	Cond-ition	Score	Notes
Document	Yes	Arguments	Yes	10	Excellent and outstanding documents and evidence
Doc	Yes	Arg	Yes	9	Solid evidence available supported by clear and reasonable arguments
Doc	Yes	Arg	No	7	Solid evidence is available but not supported by clear and reasonable arguments.
Doc	Partially	Arg	Partially	5	Both evidence and arguments are presented, but they are questionable
Doc	No	Arg	Yes	3	Only verbal statements without solid evidence
Doc	No	Arg	No	0	No evidence, no arguments

The scoring table guides the assessor in scoring each subcriterion. An intermediate score may be provided when the assessor identifies mixed conditions of evidence and arguments. A summary of the reason behind the score is also provided as justification. It is necessary to highlight the reasoning behind the scores, majorly based on how each participant responds to the question. The assessor considers solid evidence for each statement or sub-criteria. An innovation or approach for each profiling aspect will be regarded as additional points. Therefore, each participant was required to present it during the survey process. Unavailability or absence of evidence needed during this period is considered a response failure and hence marked lower. However, the research team allows the participants to complete the necessary documents until the agreed deadline. The total score for each criterion is later summarised. All scores stated in the summary for each aspect are average scores.

III. RESULT

A. Survey results and data collection

The dataset of ship management companies reveals significant diversity in fleet size and trading areas, highlighting a wide range of operational capacities and geographical focuses within the maritime industry.

In terms of fleet size, the range is quite broad, from companies like L (271 ships), H (85 boats), and I (68 ships), which operate extensive fleets, to smaller operators like D, R, and U with just one ship each, and even G, which does not currently operate any vessels. Large fleet operators, particularly those managing more than 50 vessels, typically engage in international trading and often have more developed infrastructure and resources for managing complex emergencies, as seen in companies like H and L. Their scale of operation necessitates more advanced crisis management systems due to the complexities of international shipping routes and the higher stakes involved in oil and gas transport across global markets.

On the other hand, companies with small fleets, such as J (2 ships), N (3 ships), and F (2 boats), primarily operate in domestic trading areas. These smaller companies may need more resources for robust emergency preparedness programs. Their focus on domestic trade may mean less exposure to international regulatory standards, potentially affecting their crisis management strategies and overall safety protocols. However, despite their smaller size, some of these companies still show an ability to manage emergencies effectively, though their performance in this area tends to be more inconsistent compared to their larger counterparts.

The trading areas of these companies further highlight the diversity of their operational environments. Companies operating in international trading areas like K, I, and M generally face stricter global regulations and more complex logistical challenges. As a result, these companies are often pushed to adopt more sophisticated systems for crisis management, ensuring compliance with international standards. In contrast, companies focused on domestic trading, like C (31 ships), P (13 ships), and T (9 ships), tend to operate within the boundaries of national regulations, which can differ significantly from international standards. This often results in varying levels of preparedness, with domestic operators generally facing less regulatory pressure to maintain the same level of crisis readiness.

There is also a group of companies, such as A (7 ships), M (6 ships), and U (1 ship), that are national affiliates but operate internationally. These companies straddle the line between national and international operations, benefiting from domestic ties and global exposure. This dual affiliation can offer advantages regarding regulatory flexibility and access to a broader range of resources. However, it may also introduce complexities in balancing the differing standards of domestic and international maritime regulations.

The dataset illustrates a rich diversity in fleet size and trading areas, reflecting the varied scope of operations within the ship management sector. Large international companies tend to have more extensive resources and advanced crisis management systems driven by global oil and gas transport demands. While more limited in scope, more minor, domestically focused companies still play a crucial role in the industry, though their preparedness for emergencies can vary widely. This diversity underscores the need for tailored approaches to crisis management and safety practices, depending on the size of the fleet and the trading areas in which a company operates.

TABLE 3 PARTICIPATING COMPANIES ARE BASED ON FLEET SIZE, TRADING AREA, AND STATE OF BUSINESS OWNERSHIP.

Ship Mgmt Company	Fleet Size	Trading Area	Business ownership
A	7	International	National Affiliate International
B	12	International	National
C	31	Domestic	National
D	1	Domestic	National
E	54	International	National
F	2	Domestic	National
G	0	N/A	National
H	85	International	International
I	68	International	International
J	2	Domestic	National
K	11	International	International
L	271	International	International
M	6	International	National Affiliate International
N	3	International	National
O	27	International	National
P	13	Domestic	National
Q	3	Domestic	National
R	1	Domestic	National
S	8	Domestic	International
T	9	Domestic	National
U	1	International	National Affiliate International
W	4	International	National
X	7	Domestic	National

B. *Scoring Result and Analysis of The Findings*

The evaluation results indicate that Company H stands out as the best-performing company, with an average score of 9.25. This company exhibits excellence in all areas of emergency preparedness, including crisis management, vessel and shore-based responses, and business continuity planning. The company's high score in areas such as media interaction and crisis management resources (Q5 and Q8) suggests a well-structured response mechanism for handling emergencies efficiently, both from an operational and a public relations standpoint.

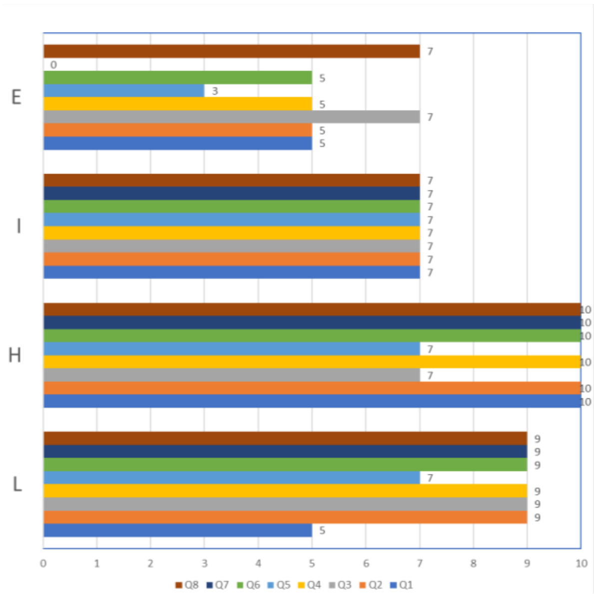

Fig. 4. Evaluation results for high-tier ship management companies (more than 50 vessels in their fleet)

With a TMSA stage of 3.75, Company H sets a benchmark for other companies by demonstrating what a comprehensive emergency preparedness system should look like. Their preparedness is backed by detailed documentation and well-developed procedures.

Company L, with an average score of 8.25 and a TMSA stage of 3.75, follows closely behind. It performs exceptionally well in shore-based emergency response (Q3) and business continuity planning (Q6 and Q7).

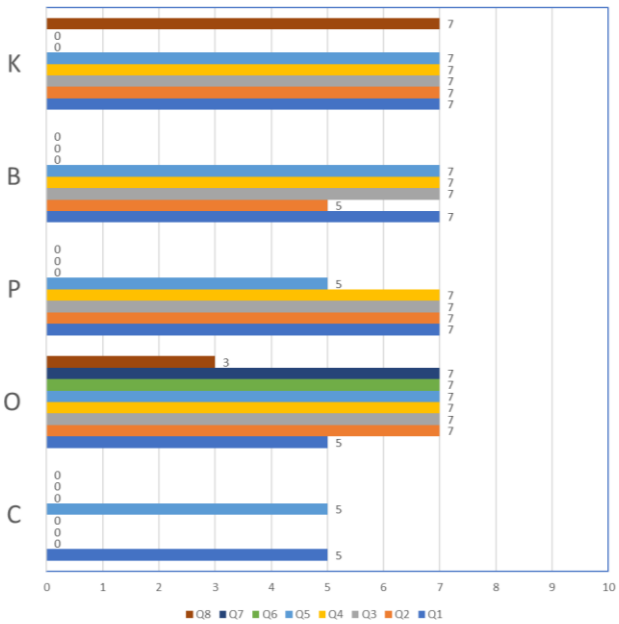

Fig. 5. Evaluation result for ship management company under middle tier (10 – 50 vessels in the fleet)

The company's documentation and evidence suggest that it has invested heavily in preparing for shore-based crises, essential for mitigating oil and gas transport risks. However, there is some room for improvement in vessel emergency response (Q1 and Q2), where the company, while still performing well, could benefit from more detailed notification procedures to handle credible emergency scenarios on board. Company I also performs well, with an average score of 7.00 and a TMSA stage of 4.00, showcasing a balanced approach to emergency preparedness. This company consistently scored solid marks across all categories, including crisis management facilities and media interaction. The company's stable performance indicates a comprehensive preparedness plan, although improving specific areas like business continuity could elevate its emergency response capabilities even further.

Several companies fall within the mid-tier performance range, with average scores between 4 and 6. Company O scores 6.25, with a strong showing in crisis management and emergency response, particularly in the vessel and shore-based response categories. However, the company must catch up in business continuity planning (Q6 and Q7) and crisis management resources (Q8), which are critical for managing prolonged disruptions. Company O should strengthen its business continuity plan to improve its overall preparedness and ensure it is equipped to maintain operations during unexpected disruptions. Company P, with an average score of 4.13, performs adequately in vessel and shore-based responses (Q1-Q3) but shows significant weaknesses in business continuity and crisis management resources. The lack of a formalised business continuity plan leaves Company P vulnerable to disruptions, which could severely impact its operations during a crisis. Similarly, Company N (average score 5.50) has solid vessel and shore-based responses but needs to enhance its media interaction procedures (Q5) and further develop its business continuity strategy. Both companies need to prioritise improving these areas to reach the level of the top performers.

At the lower end of the spectrum, companies like C, G, and Q exhibit significant deficiencies in their emergency preparedness. Company C has an average score of 1.25 and a TMSA stage 3.00, reflecting minimal preparedness. The company needs documentation for shore-based emergency response (Q3) or crisis management facilities (Q4), leaving it highly vulnerable in emergencies. Its lack of business continuity planning (Q6 and Q7) further compounds the risk, making it one of the most underprepared companies in the evaluation.

Similarly, Company G scores 1.88, reflecting significant gaps in emergency preparedness, especially in business continuity and shore-based emergency response. These critical elements are necessary for the company to manage emergencies effectively, putting its operations at risk. Company Q, with an average score of 1.63, shows poor performance across most categories, offering little evidence of preparedness for either vessel or shore-based crises. These companies must develop and document comprehensive crisis management and business continuity plans to avoid significant operational and safety risks. One of the most glaring trends observed across most companies is the lack of comprehensive business continuity planning. Questions Q6 and Q7, which assess a company's ability to maintain operations during significant disruptions, revealed that many companies, including A, B, E, F, J, M, P, S, T, U, W, and X, scored "0" in this category. Business continuity is essential for oil and gas transporters, especially given the high-stakes nature of their operations. A lack of formal business continuity plans exposes these companies to prolonged downtime or catastrophic operational failure in the event of major disruptions such as natural disasters, cyberattacks, or industrial accidents. This is a critical gap that needs immediate attention across the industry.

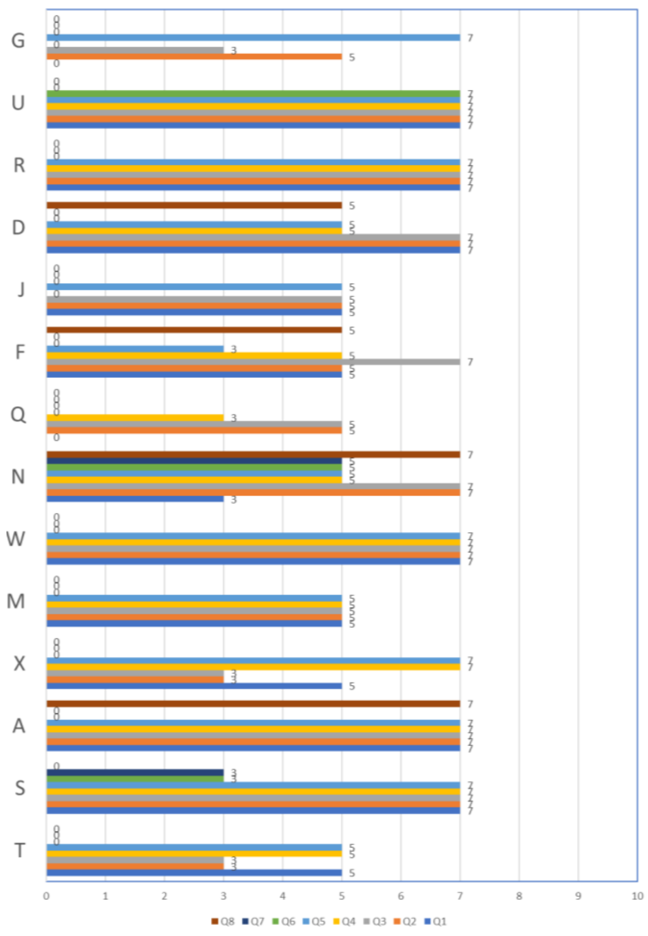

Fig. 6. . Evaluation result for ship management company under lower tier (less than ten vessels in the fleet)

Another significant issue is the need for more effective shore-based emergency response systems. Companies such as C, G, J, Q, and T scored poorly in this area, suggesting they may not be equipped to handle emergencies requiring coordination between their vessels and onshore operations. A robust shore-based response system is crucial, as it allows companies to manage crises effectively remotely, coordinate rescue operations, mitigate environmental damage, and ensure the safety of their crews and assets. Additionally, many companies must provide adequate crisis management facilities (Q4) to handle emergencies efficiently. Companies like C, G, J, Q, T, and M must present sufficient evidence of suitable facilities, meaning they may need the physical or technological infrastructure to manage a crisis. This could lead to delays in decision-making or communication, both of which are critical during an emergency. Lastly, media interaction procedures (Q5) were lacking across several companies, including E, F, J, T, and Q. Effective media management is crucial during a crisis to prevent misinformation and protect a company's reputation in today's highly connected world. Without clear procedures, companies could be overwhelmed by public and media scrutiny, further complicating their response to an emergency.

The evaluation of emergency preparedness across these ship management companies highlights various performances. While companies like H, L, and I lead the way with comprehensive and well-documented crisis management systems, many others, particularly C, G, and Q, have significant gaps that need urgent attention. The most critical issues observed across all companies are the need for business continuity planning and adequate shore-based emergency response systems. Addressing these issues would significantly enhance the industry's ability to manage crises and maintain operational resilience.

IV. DISCUSSION

Identifying emergencies is essential for creating specific, targeted procedures that ensure crews are not unprepared. Company policies should regularly review and update the list of potential emergencies as part of their continual improvement process, considering new risks, lessons learned from incidents, or regulation changes. The ISM Code requires companies to establish written procedures for responding to the identified emergencies. These procedures should provide clear, step-by-step guidance to the crew on how to act during emergencies. Procedures should cover Immediate actions to control or contain the situation (e.g., fire suppression, damage control), communication protocols with shore-based management, relevant authorities (e.g., port control, coast guard), and emergency services. In addition, the company procedure also needs to ensure that evacuation procedures in extreme situations, Use of onboard emergency equipment (firefighting equipment, life-saving appliances, etc.) and Environmental protection measures (e.g., oil spill containment and cleanup) are readily available.

The company's SMS must include emergency response procedures tailored to each vessel's operations and the identified risks. These procedures must be easy to understand and accessible to the crew at all times. Company policy should ensure that the methods are reviewed regularly and updated based on feedback from drills, natural emergencies, or regulation changes. The company's shore-based management is crucial in supporting the ship during emergencies. Thus, company policies must emphasise the importance of coordination between the vessel's crew and the shore team to ensure swift decision-making and resource allocation during emergencies. Element 8 emphasises the importance of drills and exercises in preparing crews for emergencies. Drills allow the crew to practice the emergency procedures regularly, ensuring they understand their roles, can work together efficiently, and are familiar with the equipment they need to use. The types of drills mandated include Fire drills, abandoned ship drills, man overboard drills, Oil spill response exercises, and Emergency steering and engine control drills. These drills should be scheduled at regular intervals (monthly, quarterly, etc.) and include a variety of scenarios to cover all potential emergencies. Additionally, joint exercises between the crew and shore-based personnel can be beneficial to test communication protocols and shore-based support. The company's SMS must specify the frequency and type of drills required on each vessel. Policies should ensure that drills are not routine exercises but realistic simulations of actual emergencies. This includes randomly simulating emergencies without prior warning to test the crew's ability to respond under pressure. Company policies must also outline how drills are to be documented and analysed. Feedback from these drills should be used to improve emergency procedures, identify training gaps, and address any issues with equipment. Furthermore, the policy should ensure that drills are aligned with regulatory requirements and industry best practices.

The ISM Code requires that companies take the necessary measures to respond to emergencies. This includes ensuring that both onboard crew and shore-based management are prepared to act in a coordinated and timely manner. Measures should include 24/7 emergency contact points between the vessel and shore-based management, access to emergency supplies, including firefighting equipment, oil spill response kits, and life-saving appliances, pre-determined roles and responsibilities for each crew member during an emergency, and Protocols for engaging with external emergency response agencies (e.g., coast guards, environmental response teams). Company policy must ensure that emergency measures are always in place, not just during drills. For example, the policy should ensure that all equipment is regularly maintained and ready for immediate use. Emergency response kits should be inspected routinely, and safety equipment must meet regulatory standards. Moreover, shore-based emergency response teams must be well-trained and available 24/7. Company policies should clearly define the roles and responsibilities of the shore-based team in supporting shipboard operations during an emergency. This includes ensuring that appropriate personnel are always available to provide technical advice, coordinate with external responders, and manage communication between the vessel and relevant authorities.

Emergency preparedness under Element 8 is not static; companies must continually monitor their performance and improve their preparedness through lessons learned from drills, exercises, and incidents. This also includes analysing near-misses and using feedback to enhance emergency response procedures and crew training. Company policies should foster a culture of continuous improvement, where input from drills, incident reports, and audits is actively used to refine emergency response procedures. Companies should implement mechanisms for reporting, investigating, and analysing incidents or near-misses, ensuring that any deficiencies in emergency preparedness are addressed swiftly. This process may involve revising procedures, updating training programs, or investing in new technology and equipment to enhance emergency response capabilities. Policies should also promote transparency, sharing learnings from emergencies across the company's fleet to ensure that all vessels benefit from lessons learned on a single ship.

The analysis reveals that fleet size influences ship management companies' performance in terms of emergency preparedness, though this relationship is only sometimes straightforward. Companies with large fleets (over 50 vessels), such as H (85 ships) and L (271 ships), performed the best, with average scores of 9.25 and 8.25, respectively. This suggests that larger companies tend to have more robust emergency preparedness systems. Their size likely necessitates sophisticated crisis management protocols to handle the complexity and scale of operations, especially in high-risk sectors like oil and gas transport. These companies also benefit from more significant resources, which may help them develop and implement better systems for crisis management, media handling, and business continuity.

However, not all large companies follow this trend. Despite being a large company, Company E (54 ships) scored only 4.63, indicating that having a large fleet size does not automatically translate to high performance in emergency preparedness. This suggests that fleet size alone does not ensure excellence in crisis management, and internal organisational priorities, leadership focus, and investments in emergency preparedness also play crucial roles. Conversely, small fleet operators exhibit more varied performance. Companies with fewer vessels, such as D (1 ship) and R (1 ship), scored 4.50 and 4.38, showing that smaller operators can maintain effective emergency systems. However, others, like F (2 ships) and J (2 boats), scored lower, at 3.75 and 2.50. This inconsistency indicates that smaller companies may lack the resources or experience to develop robust crisis management frameworks. However, those that prioritise emergency preparedness can still perform relatively well.

The trading area—whether the company operates internationally or domestically—also correlates with performance in emergency preparedness. Companies operating in the international trading area tend to perform better overall. For instance, H (9.25), I (7.00), and L (8.25), all of which operate internationally, had the highest evaluation scores. This could be because international operations expose companies to stricter regulatory environments, higher safety standards, and more complex emergency scenarios, which forces them to adopt better crisis management policies. On the other hand, companies operating primarily in domestic trading areas generally scored lower. C (1.25), J (2.50), and T (2.63), for example, all have relatively low scores despite having moderate to large fleets. This indicates that domestic companies may not face the same regulatory pressures or operational complexities as their international counterparts. As a result, they may not prioritise emergency preparedness to the same extent. However, some domestic companies, like P (4.13) and S (5.13), performed relatively well, showing that solid emergency preparedness is achievable even for companies focused on domestic operations.

The TMSA stage (Tanker Management and Self-Assessment) offers another important insight into the relationship between fleet size, trading area, and crisis management capabilities. Companies with higher TMSA stages, like H (3.75), I (4.00), and L (3.75), also have some of the highest evaluation scores, confirming that a higher TMSA stage correlates with better performance in emergency preparedness. These companies have more mature management systems, including detailed emergency response plans, business continuity strategies, and media handling procedures, all contributing to their ability to respond effectively to crises. In contrast, companies with lower TMSA stages, such as F (2.60), N (2.20), and T (2.00), tend to score lower in their evaluations. This shows that companies at the lower end of the TMSA spectrum often need more preparedness, which may leave them vulnerable to crises, especially in the high-risk oil and gas sector. Lower TMSA stages indicate that these companies may still need to fully develop or test their crisis management systems, making them less capable of handling emergencies effectively. From this analysis, several significant issues emerge regarding the state of emergency preparedness among these ship management companies, particularly in the oil and gas transport sector.

Inconsistency in Crisis Management Systems was also identified during the survey stage. A recurring issue across many companies is the need for more consistency in developing crisis management systems. While some companies excel in creating detailed plans and securing resources, others need more formalised systems or present only verbal assurances without supporting evidence. This inconsistency is especially prevalent among companies with smaller fleets or those operating domestically. On the other hand, in business continuity planning, many companies scored poorly on business continuity, with several receiving scores of 0 on questions related to continuity planning. This indicates a widespread lack of preparation for potential disruptions to their business operations, a critical vulnerability in the oil and gas sector, where continuous operations are essential. Concerning media Handling and Crisis Communication, The evaluation results also reveal a significant gap in media handling and crisis communication. Several companies, especially those with lower TMSA stages, do not have adequate procedures or resources to manage public relations during a crisis, which could lead to reputational damage and operational delays in an emergency. From another point of view, disparities between domestic and international companies are apparent.

Companies operating internationally tend to perform better in emergency preparedness evaluations, while domestic companies lag. This suggests that domestic operators may not be as exposed to stringent regulatory requirements or may not prioritise crisis management due to perceived lower risks. However, given the critical nature of oil and gas transport, this gap represents a significant area for improvement for domestic operators. Resource Allocation for Crisis Management: Many companies, regardless of size or trading area, lack additional resources dedicated to crisis management, which is particularly concerning—in a large-scale emergency, having a reserve of resources—whether personnel, equipment, or financial backing—can make the difference between effective crisis resolution and operational failure.

V. Conclusion

The research focuses on how the ship management company put in place its strategies for dealing with emergency situations that may exist in its operation. The company must maintain its records to identify potential emergencies within its business process scope. There were several approaches to handling such issues, such as setting up policies and guidelines, providing emergency response facilities, and training the entire parties to familiarise the whole company when dealing with emergencies.

The analysis shows a clear correlation between fleet size, trading area, and emergency preparedness, though factors like company maturity and regulatory exposure influence it. Larger fleets and international operations often correlate with better performance. Still, internal management systems, as reflected in the TMSA stages, are critical in determining a company's readiness to handle emergencies. Significant issues like weak business continuity planning, inadequate media handling, and inconsistent crisis management systems represent crucial vulnerabilities across the sector, especially for domestic operators. Addressing these gaps will be essential to improving the overall emergency preparedness of ship management companies involved in oil and gas transport. This finding is a resourceful reference for every stakeholder to strengthen their readiness to handle emergencies.

Additional research comparing company procedures with actual ship readiness conditions can improve the outcome of this research. This research will identify the significant and potential gap between policy and implementation.

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