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Στη ΝΑΥΤΙΛΙΑ

DISRUPTION MANAGEMENT IN SHIPPING:

STRATEGIES AND TECHNOLOGIES FOR MITIGATING RISKS

Δήμητρα Αγραφιώτη

Διπλωματική Εργασία
που υποβλήθηκε στο Τμήμα Ναυτιλιακών Σπουδών του Πανεπιστημίου Πειραιώς ως μέρος των απαιτήσεων για την απόκτηση του

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The members of the Committee:

- Ioannis Theotokas (Supervisor)

- Dimitrios Mattheou

- Dionysios Polemis

The approval of the Thesis by the Department of Maritime Studies of the University of Piraeus does not imply acceptance of the views of the author.

Preface

Shipping is a sector reinforced with international organizations, regulations and procedures, comprising a framework to support its activities and enhance the safety and security of its people, assets and environment, but in the face of internal or external threats, it can become vulnerable. In this Dissertation, the author aims to provide a comprehensive view of risks and disruptions in shipping, and strategies and technologies to anticipate and combat them. At the time of writing this Dissertation, various external and internal factors have been creating disruptions in shipping, and in the recent past risks have been evolving and increasing. It is, thus, timely to explore strategies and technologies, examine recent disruption cases, and review the risk management approach of a tanker company, to provide a comprehensive view of disruption management that could be useful to the shipping community and ground for further research.

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Dedicated to my mother.

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Abstract

This dissertation aims to offer insights on disruption management and risk mitigation in various aspects of shipping, examining current strategies and technologies that could be used. This dissertation uses an assortment of sources, both scientific and empirical, something that, in the author's opinion, is in line with shipping's nature. The bibliography, strategies and technologies adopted by the industry, case studies and an actual risk-management scenario, to provide a preliminary but at the same time comprehensive view on risk mitigation strategies and technologies and the management of disruptions in shipping. It is established that managing disruptions is benefited by a multifaceted approach, that includes proactive and reactive strategies, and the use of technologies to reduce disruptions and risks. From the disruption cases studied it was concluded that shipping companies need to constantly pursue compliance with international regulations, invest in proactive strategies, aim for continuous improvement through review of existing management systems, streamline their existing reactive strategies, initiate and strengthen cooperation across the industry, and invest in new technologies and cyber-security.

Key Words: Disruption, Disruption Management, Risk Mitigation, Shipping, Risk Assessment, Strategies, Technologies

Περίληψη

Ο στόχος αυτής της διατριβής είναι να παρέχει μια όσο το δυνατόν πιο ολοκληρωμένη εικόνα για τη διαχείριση διαταραχών και τον μετριασμό του κινδύνου σε διάφορες πτυχές της ναυτιλίας, διερευνώντας τις υπάρχουσες στρατηγικές και τεχνολογίες που θα μπορούσαν να χρησιμοποιηθούν. Για το λόγο αυτό, χρησιμοποιήθηκαν ποικίλες πηγές, τόσο επιστημονικές όσο και εμπειρικές, κάτι που, κατά τη γνώμη της συγγραφέως, είναι σύμφωνο με τη φύση της ναυτιλίας. Η βιβλιογραφία με τις στρατηγικές και τεχνολογίες που υιοθετήθηκαν από τον κλάδο, οι περιπτωσιολογικές μελέτες και ένα πραγματικό σενάριο διαχείρισης κινδύνου, χρησιμοποιήθηκαν για τη δημιουργία μιας προκαταρκτικής αλλά ταυτόχρονα όσο το δυνατόν πιο περιεκτικής άποψης για την αντιμετώπιση διαταραχών και τον μετριασμό κινδύνων που μπορεί να παρουσιαστούν στο χώρο της ναυτιλίας. Διαπιστώθηκε ότι η διαχείριση των διαταραχών και η μείωση των κινδύνων, επωφελούνται από μια πολύπλευρη προσέγγιση, η οποία περιλαμβάνει προληπτικές και αντιδραστικές στρατηγικές και τη χρήση τεχνολογιών.

Λέξεις Κλειδιά: Διαταραχή, Διαχείριση Διαταραχών, Μετριασμός Κινδύνου, Ναυτιλία, Εκτίμηση Κινδύνου, Στρατηγικές, Τεχνολογίες

Abbreviations	Definitions
AIS	Automated Identification Systems
BIMCO	The Baltic and International Maritime Council
BMP	Best Management Practices
CEO	Chief Executive Officer
CMA CGM	Compagnie Maritime d'Affrètement Compagnie Générale Maritime
COSCO	China Ocean Shipping Company
DPA	Designated Person Ashore
ECDIS	Electronic Chart Display and Information System
EEOI	Energy Efficiency Operational Indicator
FSA	Formal Safety Assessment Process
GMDSS	Global Maritime Distress and Safety System
GPS	Global Positioning System
GT	Gross Tonnage
HAZID	Hazard Identification
HSEQMS	Health Safety Quality and Environmental Management System
HSQE	Health Safety Quality and Environment
IBM	International Business Machines Corporation
ILC	International Labour Conference
IMB	International Maritime Bureau
IMO	International Maritime Organization
IoT	Internet of Things
IR	Initial Risk
ISM	International Convention for the Safety of Life at Sea
ISPS	International Ship and Port Facility Security Code
IT	Information Technology
MARPOL	International Convention for the Prevention of Pollution from Ships
ML	Machine Learning
MLC	Maritime Labour Convention
MOB	Man Overboard
MSC	Maritime Safety Committee
MSC (company)	Mediterranean Shipping Company
OECD	Organization for Economic Cooperation and Development

OT	Operational Technology
P&I	Protection and Indemnity
PPE	Personal Protective Equipment
RA	Risk Assessment
RAM	Risk Assessment Matrix
RFID	Radio Frequency Identification
RR	Residual Risk
SMS	Safety Management System
SOLAS	International Convention for the Safety of Life at Sea
SRA	Society for Risk Analysis
STCW	Standards of Training, Certification, and Watchkeeping Convention
STS	Ship to Ship
TEU	twenty-foot equivalent unit
UNCLOS	United Nations Convention on the Law of the Sea
VCR	Voluntary Community Reporting

Chapter 1: Introduction

Shipping is the cornerstone of global trade and strives to operate like a fine-tuned machine, as it is responsible for transporting goods and commodities around the world. Even Though it is enriched by centuries worth of knowledge, experience, research, improvements, technological innovation, and countless hours of labor, it has yet to become immune to disruptions and risk. As an interconnected and interdependent domain with innate complexity, shipping is continuously being exposed to risks. Thus, it can quickly become vulnerable to disruptions as it incorporates many different factors that have to work in conjunction in order to achieve the desired result; the successful completion of the transport work.

The topic of this dissertation was chosen in the light of the increasing frequency and growing impact of disruptions in the shipping industry. Disruptions are events or situations that cause deviations from the original plan, and they can happen any time during a maritime transportation work. Their effective management is a timely topic within the shipping industry, amidst the current worldwide events, as the impact of an unmanaged disruption can lead to unwanted situations, performance issues, and losses for the shippers and the carriers.

Therefore, it could be interesting to explore strategies and technologies applied to mitigate risks in the shipping industry, which is the objective of this paper, as well as to identify different types of disruptions that may occur in the shipping industry and evaluate the effectiveness of various strategies and techniques to address these disruptions. Supportive to the above, existing literature will be reviewed along with recent disruption cases that impacted the industry to provide a comprehensive view on disruptions, as well as risk mitigation strategies, and technologies used to reduce their impact. To provide more insight on shipping companies' approach of risk-assessment for their day-to-day operations, an esteemed tanker management company's risk-assessment will be presented, concerning an activity that one of its vessels must engage in using the relevant material, as provided by the shipping company. Key findings and challenges will then be presented and best practices and recommendations for future research will be provided.

Chapter 2: Literature Review

2.1 Disruptions and Shipping

The Importance of Shipping for Global Trade

The history of transportation of goods by sea can be traced back 5,000 years, according to Stopford (Stopford, 2009). Shipping's central and foundational role in the world economy cannot be denied, as it is an integral sector of global trade that enables the distribution of goods, commodities and raw materials across the world. O fcourse, shipping's greatness does not exclusively lie in its extensive history, but also in its vast contribution towards the advancement of the contemporary world.

From simple fishing boats to state-of-the-art modern ships built to facilitate the exchange of commodities within and across international borders, in its years and years of rapid growth and evolution, shipping has come to be one of the most prosperous, complex, and crucial links of the global supply chain network. This is the reason why its continuous, uninterrupted operation is of great importance.

While the ship itself is the means of transport for the seaborne trade and, undeniably, one of the most important organisms in the ecosystem that is the maritime supply chain, great coordination between many individual components is required, for the execution of a transport work. As a complex system, shipping is composed of integrated nodes, such as seaports, dry ports and intermodal depots, and links, such as the sea transport between key seaports, and shore-based modes of transport connecting seaports with the hinterland. Due to its complexity, a considerable number of stakeholders including shippers, shipping lines, port authorities and operators, hinterland transport operators, marine and cargo insurers, and banks amongst others, cooperate daily and are members of interdependent relationships within the various processes of shipping (Nguyen et al., 2023).

Shipping, apart from enabling the transportation of goods and commodities in any location across the globe, also provides employment opportunities for a great number of employees and workers around the world through its interconnected network. Seafarers, crew, office employees, port workers, freight-forwarders, etc. are very few of the jobs that shipping supports.

The Resilience of Shipping: Overcoming Obstacles

Sea transport cannot always remain unaffected in the occurrence of major global events. During the COVID-19 pandemic the maritime sector faced challenges such as disruptions within the supply chain, port operations, port congestion, and crew management issues such as the crew change crisis of 2020[1]. Moreover, nations' interdependency was shaken by imposed containment measures, due to the implementation of strict COVID-19 policies and measures such as operating limitations affecting borders and ports[2], travel restrictions and entry bans[3], "stay at home" and *Zero Covid*[4] policies, in an attempt to combat the transmission of the virus by minimizing social interaction and mitigate the effects of the pandemic.

Despite the unfavorable circumstances the shipping industry faced, it managed to overcome the challenges and continue its operation. During the COVID-19 pandemic, in 2020 UNCTAD reported that 80% of international trade was still being facilitated by sea transportation.

The United Nations Conference on Trade and Development (UNCTAD) in its 2021 report states that eleven (11) billion tons of goods have been transported by ships, with a shipment volume increase of 3.2%, compared to 2020, because of high demand in containerized cargo (UNCTAD, 2022).

With the intergovernmental organization reporting a decrease of 0.4% for 2022, mainly impacted by the major geopolitical event of the ongoing war in Ukraine, one could assume that the shipping industry would be soon facing another decline. UNCTAD's report for 2023 suggests that this assumption would not be the case, with the organization forecasting a 2,4% rebound in maritime trade volume within 2023, and forecasted an increase by over 2% till 2028. UNCTAD

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[1] The COVID-19 pandemic: The crew change crisis, International Chamber of Shipping, 2020

[2] Trade Facilitation and the COVID-19 Pandemic, Organisation for Economic Co-operation and Development, 22 April 2020

[3] "Coronavirus Travel Restrictions, Across the Globe". *The New York Times*. 26 March 2020.

[4] Lupi, A et al., "What Is a Zero- COVID Strategy and How Can It Help Us Minimise the Impact of the Pandemic?", 27 November 2020.

makes a point by bestowing that growth upon the high resilience of the maritime industry (UNCTAD 2023).

The resilience and adaptability showcased in the examples above, despite facing major crises, has undeniably been one of the many factors contributing to shipping's thousand-year long success.

The Impact of Disrupted Operations.

Transport work executed in the best possible manner results in satisfied stakeholders such as the end user of the transported product, individual businesses, other supply chain stakeholders and even entire nations. When a disruption is not managed effectively the negative impact can make its way through multiple branches of the shipping operation, and it is essential to consider the economic and potential social consequences. For instance, disruptions in the supply chain can affect the global economy and people's daily lives.

Financial Consequences

It is not just major events such as global pandemics and wars that can negatively impact the shipping industry. A disruptive event has the potential to affect performance, leading to increased risks and disruption of the shipping operations and financial consequences. For instance, the Suez Canal's blockage in 2021 had severe financial impact resulting in the loss of $9.6 billion per day for trade, or $6.7m a minute, since the Suez Canal accommodates 12% of global trade each day. This blockage, apart from being a significant disruption for global trade, had financial consequences for stakeholders and affected countless businesses. (Russon, 2021)

Effects on Reputation

In the shipping industry one of the most important factors for the success of a company is its good reputation. The effective management of disruptions by implementing safety and quality management in shipping along with strategies and technologies, can eliminate or prevent the occurrence of such events, or mitigate their consequences, maintaining the good reputation of the company (Mattheou, 2023). Of course, it is not always given that obstacles and disruptions can be avoided; Unfavorable circumstances, limited reaction time, delays, and factors/events beyond its control, might not allow the shipping company to rectify the performance affecting event. The shipping company will then have to contain the reputational damage.

2.2 Overview of Key Concepts and Theories

Within this chapter, it is attempted to lay out a theoretical framework with definitions and terms relating to Risk and Disruptions, as provided by experts.

2.2.1 Risk and Risk Management

It is useful to consider definitions provided by established scholars and bodies such as the International Organization for Standardization, and The Society for Risk Analysis (SRA), to attempt to interpret them through the prism of *Disruption Management* (See Ch. 2.2.2).

In ISO 31000 (Risk management)

Risk is defined as *"The effect of uncertainty on objectives."*
Risk Management as the "*coordinated activities to direct and control an organization with regard to risk"* , and
Risk Management Process as *"A systematic application of management policies, procedures and practices to the tasks of communication, consultation, establishing the context, identifying, analyzing, evaluating, treating, monitoring and reviewing risk"*
(International Organizations for Standardization, 2018).

The International Maritime Organization (IMO) in its Revised Guidelines For Formal Safety Assessment (FSA) terminology, defines

Risk as *"The combination of the frequency and the severity of the consequence."*

Frequency is defined as "*the number of occurrences per unit time (e.g. per year)*", and severity ranging from 1 to 4: *1 Minor 2: Significant 3: Severe 4: Catastrophic.* (IMO, 2018)

Aven in his paper, summarizes the **risk definition** text as provided **by the SRA**[5] , as per the below qualitative definitions, all adding the element of *uncertainty to events and consequences*:

[5] https://www.sra.org/

“*(a)the possibility of an unfortunate occurrence,*

(b)the potential for realization of unwanted, negative consequences of an event,

(c)exposure to a proposition (e.g. the occurrence of a loss) of which one is uncertain,

(d)the consequences of the activity and associated uncertainties,

(e)uncertainty about and severity of the consequences of an activity with respect to something that humans value,

(f)the occurrences of some specified consequences of the activity and associated uncertainties,

(g)the deviation from a reference value and associated uncertainties.” (Aven, 2015)

According to the International Organization for Standardization (ISO):

Hazard is “the potential source of harm” and it can be also defined as “any real or potential condition that can cause injury, illness, or death to personnel; damage to or loss of a system, equipment, or property; or damage to the environment.” (Ericson, 2005)

Hazardous situation is a “circumstance in which people, property or the environment is/are exposed to one or more hazards”

Risk is “the combination of the probability of occurrence of harm and the severity of that harm. The probability of occurrence includes the exposure to a hazardous situation, the occurrence of a hazardous event (and the possibility to avoid or limit the harm.”

Risk Analysis is the “systematic use of available information to identify hazards and to estimate the risk.”

Risk Assessment is the “overall process comprising a risk analysis and a risk evaluation”

Risk Evaluation is the “procedure based on the risk analysis to determine whether tolerable risk has been exceeded”

Tolerable/Acceptable Risk is “the level of risk that is accepted in a given context based on the current values of society.

(*ISO 9001:2015(en), Quality Management Systems — Requirements*, 2014)

2.2.2 Risk Metrics & Descriptions

To assess risk, various metrics can be used. Aven argues that a situation can define each metric's suitability, as for decision support in a specific situation, a selection of metrics has to be determined. (Aven, 2015)

Examples of Risk Metrics & Descriptions as presented by Aven:

"1. The Probability and magnitude/severity of consequences combination

2. The Triplet (si , pi , ci)[6]

3. The Triplet (C', Q, K)[7]

4. Expected consequences (damage, loss), for example computed by:

(i) Expected number of fatalities in a specific period of time or the expected number of fatalities per unit of exposure time

(ii) The product of the probability of the hazard occurring and the probability that the relevant object is exposed given the hazard, and the expected damage given that the hazard oc- curs and the object is exposed to it (the last term is a vulnerability metric).

(iii) Expected disutility.

5. A probability distribution for the damage (for example a triangular possibility distribution)" (Aven, 2015).

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[6] *S*i : the *i*th scenario, pi: the probability of that scenario, ci: the consequence of the *i*th scenario, *i* =1,2, ...N

[7] C' is some specified consequences, Q a measure of uncertainty associated with C' (typically probability) and K the background knowledge that supports C' and Q.

2.2.3 Disruption and Disruption Management

As per authors Yu and Qi, in general, any event that causes deviation from the original plan, affecting the system's performance, regardless of its cause and nature, can be denoted as a disruption. Those changes may originate from various external, or internal factors, and can include possible issues included in the planning phase, as well as difficult or impossible situations to anticipate. (Yu & Qi, 2004).

As per Elmi et al. it is important to emphasize that "Disruptions are common not just for container shipping, but also for shipping of liquid and dry bulk cargoes (Elmi et al., 2022)".

In this paper it is attempted to create categories based on the type of disruptions that may emerge. The work of authors Yu and Qi will be utilized to facilitate the categorization. The types of disruptions will be categorized under: **Natural Disruptions**, **Man-made Disruptions**, **Technical Disruption** and **Economic Disruptions**.

Authors Yu and Qi have categorized the sources of disruptions as (i) Changes in System Environment, where the environment of operation has undergone unexpected changes and the system's performance has been affected. Examples the authors provide for such changes is an unexpected *typhoon* impacting logistics near harbor areas, and *snowstorms* affecting air and ground transportation (Yu & Qi, 2004). Such types of disruptions occur due to natural events and are included in the **Natural Disruptions** type. The authors introduce (ii) Unpredictable Events, and include spontaneous and unanticipated events, namely, terrorist attacks, union strikes, power outages, etc. The first two examples could be categorized under the **Man-Made Disruptions** type, and the third under **Technical Disruption** type. Changes in market price for raw materials, change in delivery time from vendors, are mentioned as examples of another category, (iii) Changes in System Parameters which fits the **Economic Disruptions** type. Yu and Qu, continue with (iv) Changes in Availability of Resources caused due to failure (i.e. machine failure), quality reasons (resignation) and sickness (human resources). The first example fits the **Technical Disruption** type, and the last two examples fit into the **Human Factor** type. The authors introduce the (v) New Restrictions category, under which they include any additional restrictions that negatively impact the original plan, for example, new union contracts or new industry regulations. This description may fit into the **Man-made Disruptions** category, which may include any disruptions caused by human activities, or even the **Technical Disruptions** category**,** if, for example, the disruption is related to changes in technical regulations. Similarly. The Uncertainties in System Performance (vi) can be related to the **Man-made Disruptions** category, as authors give the examples of delays within a project and missing deadlines. The final category introduced by Yu and Qi is (vii) New Considerations which includes new considerations not anticipated while at the planning stage, and if not handled properly could cause costs (Yu & Qi, 2004).The example provided by the authors for this category is that of new customer orders and the system failing to respond to them, which fits the **Economic Disruptions** type. It is observed that a disruption may fall into one, two or more categories.

Disruption Management

Authors Yu and Qi define Disruption Management in business as

"obtaining an optimal or near-optimal operational plan at the beginning of a business cycle by the utilization of certain optimization models and solution schemes." (Yu & Qi, 2004).

They continue stating that when disruption occurs,

"the continuous and dynamic revision of the original plan and the introduction of a new one which reflects the constraints and objectives of the evolved environment while minimizing the negative impact of disruption, is referred to as Disruption Management."(Yu & Qi, 2004).

Yu and Qi in their definition of Disruption Management mention the business cycle as their work studies disruption management in a broader range of applications within the business environment.

Categorisation of Disruptions in Shipping

A single unmanaged event may be enough to cause a disruption in the original plan, triggering a domino effect of unfavorable events, or even result in failure to deliver the desired result. Disruptions happen daily and may originate from various sources that can be either internal, external or a combination of both. As already mentioned, disruptions hold the potential of interrupting the seamless running of planned operations which increases the risk for the company responsible for the delivery of a work. In this highly volatile environment of shipping, it is imperative that the factors that contribute to the emergence of disruptions and increase the risk, are identified and planned for.

Some examples of disruptions are delays, work accidents involving people, assets and/or the environment, adverse weather conditions, strikes, etc.

Natural Disruptions

Natural disruptions emerge from the consequences of natural disasters such as adverse weather conditions, hurricanes, and tsunamis that may lead to road closures, supply shortages, inventory imbalances, disruptions in transportation and logistics, delays and increased costs for the shipping company.

Natural disasters occur due to natural phenomena rather than human-related circumstances. The cause of a natural disaster may be weather or climate events or earthquakes, landslides and other phenomena and even combinations of them, that happen at the surface or within the planet, such as floods, hurricanes, heavy rains, wildfires, tornadoes, blizzards etc. Due to such natural hazards, the normal workflow can be interrupted leading to disruptions affecting shipping. Advances in technology can produce warnings that can predict or assess the strength of the physical forces that generate natural disasters before they cause damage (Metych, 2023).

Natural disasters may result in loss of human life or destruction of the natural environment, private property, or public infrastructure, and their individual cost may reach the tens of billions of dollars.

Some examples of disruptions caused by Nature are the heavy snowfalls halting port operations, hurricanes due to which the ship is not granted permission to sail, adverse weather conditions (such as extreme low or high temperatures), earthquakes, etc.

Man-made Disruptions

As the name itself implies, man-made disruptions in shipping are events or situations with negative impact, caused by human activities, leading to disruptions of the original plan.

Man-made disruption can be further divided into more subcategories, the most significant of them being; Geopolitical Instability, Piracy, and Human Error.

Geopolitical Instability

Since Shipping's area of operation is the globe and the nations comprising it, it cannot remain unaffected in the emergence of geopolitical instabilities. Conflicts between nations or political entities manifested in the form of sanctions, trade restrictions imposed from one country to another, hostilities and wars, can lead to delays in cargo operations and delivery, disruptions in shipping routes, endangerment of the crew, cargo and the ship, increased costs and economic losses.

Piracy & Armed Robbery

As per the International Maritime Bureau's 2023 Annual Piracy and Armed Robbery Report, 120 incidents of maritime piracy and armed robbery against ships were recorded in 2023 compared to 115 in 2022. The consequences of Piracy and Armed Robbery to the crew is kidnap, hostage, death, assault, injury, and missing. The consequences for the vessel are damage of equipment and/or property, and for the cargo is theft and/or damage. (ICC International Maritime Bureau, 2024.)

It is worth mentioning that the International Maritime Bureau (IBM) in its 2023 Annual Piracy and Armed Robbery Report, raised concern over December's 2023 successful Somali-based hijacking incident, first ever since 2017, as well as the rising number of crew taken hostage and kidnapped. The IMB, underlined that Masters and vessel owners should continue following the recommendations and reporting procedures as per the latest version of the Best Management Practices (BMP).

It is easily understood that such disruptive events of piracy or similar unlawful acts directly disrupt the operation of a vessel.

The Human Factor

Shipping is an activity that relies on people for the majority of its operations, the security and safety of the ship, the cargo and the environment. Since the human factor can be unpredictable, it can have an impact on the original plan. As already mentioned in this paper, Yu and Qi (2004) state that changes in resources, for example a resignation (crew, office, etc), may cause disruptions within the system.

Human Error

As per Sanchez-Beaskoetxea et al., one of the major contributing factors for marine accidents is direct or indirect human error, as some studies *(Fig. 1)* of the last thirty years have indicated (Sánchez-Beaskoetxea et al., 2021).

Organizations, recognising the significant role of the human element and addressing issues in the training, certification and well-being of crew, have been issuing and reviewing their guidelines and requirements throughout the years to assist in reducing accidents relating to insufficient training, fatigue, miss-communication along the crew, etc.

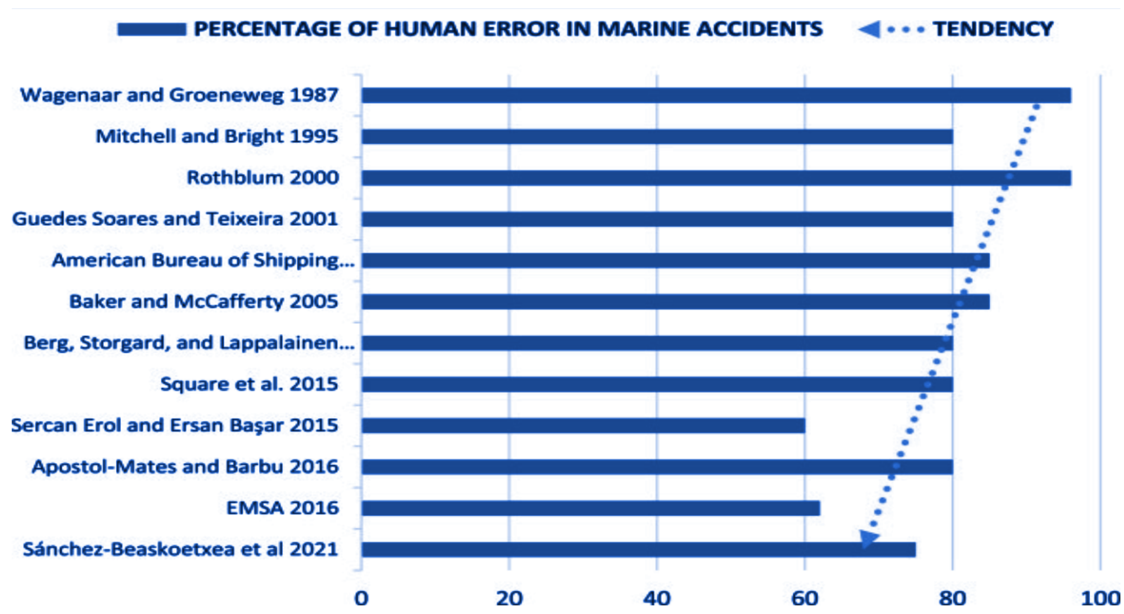

Fig. 1 Tendency and contribution of human error percentage in marine accidents according to several authors.[8]

The contribution of the International Maritime Organization (IMO) is worth noting, whose Standards of Training, Certification, and Watchkeeping Convention (STCW) of 1978 along with its subsequent amendments have been setting the minimum international standards required for Seafarers. The most recent amendment to the STCW code is the 2010 *Manila Amendments*, focused on implementing the refresher training of the STCW modules every 5 year to combat the "skills-fade" phenomenon observed. Also, the Amendment covered awareness and certification standards aspects and addressed well-being issues by increasing the resting hours to 77 within a seven-day time frame (IMO, 2019).

[8] Chart sourced from Sánchez-Beaskoetxea, J. & Basterretxea-Iribar, Imanol & Sotés, Iranzu & Machado, María. (2021). Human error in marine accidents: Is the crew normally to blame?, Maritime Transport Research. 2. 100016. 10.1016/j.martra.2021.100016.

Technical Disruptions

Non-adherence to the maintenance schedule, the inspections schedule, as well as outdated equipment, insufficient crew training, IT systems failure in shipping, logistics and port software, as well as human error can lead to technological disruptions.

Technological failures can affect the ship's operation and safety, leading to navigational errors such as grounding, collisions and other accidents with repercussions such as delays, increased repair costs, economic losses, loss of property, safety risks, environmental disasters and accidents, inevitably disrupting shipping operations.

Alianz's 2019 *Safety And Shipping Review* states that more than a third (8,862 of 26,022) of shipping incidents reported within the period of January 2009 and December 2018, were caused by *machinery damage* or *breakdown*, such as the past decade's most common cause; the engine failure. Followed by *collision* causing 3,648 incidents and *wrecked/ stranded* causing making up 3,610 of the total incidents. (Allianz Global Corporate & Specialty SE, n.d.) Comparingly, Alianz's 2023 safety review, reports that "Machinery damage or failure accounted for close to half of all incidents globally (1,478)". (Allianz Global Corporate & Specialty SE, 2023)

Economic Disruptions

Economic disruptions may occur due to various events affecting the ability of the company to respond to a financial challenge.

Market Fluctuations

The shipping sector is significantly affected by the global economy with market fluctuations impacting the ship demand. Market fluctuations are caused due to an imbalance between the supply and demand, geopolitical tension, currency fluctuations, and seasonality.

Stopford, on shipping market cycles, mentioned that in the short-term cycle which is a significant part of the market mechanism, a surplus of capacity makes the rates fall until this capacity decreases (ship scrapping) and the balance between supply and demand is restored. Seasonality is also an important factor that contributes to the volatility of the shipping sector, where trade increases and decreases depending on various elements such as harvests (agricultural commodities trade), energy consumption (oil shipments), etc. Especially for the spot market, commodities transportation may be difficult to plan accurately in advance. Liner shipping is also affected by seasonality, for example, peaks and troughs occur simultaneously during major holidays (Stopford, 2009).

Decreases in demand can lead to lay-up of vessels or ship scrapping, port congestion, increased waiting time at ports, low freight rates, poor cash flow, personnel lay-offs, and consequently, increased costs for the shipping company. On the other hand, increases in demand can make the company struggle to respond, potentially losing clients and facing increased costs.

Increased Bunker Prices

In 2008 UNCTAD reported that fuel costs constituted as much as 50–60% of total operating costs, depending on the service and type of the vessel (UNCTAD, 2010). Increases in bunker prices affect shipowners, operators and charterers, consequently affecting trade and prices.

Inflation

High inflation rates are viewed as harmful to the global economy and create difficulties for companies in terms of budgeting and planning, decreasing productivity, as companies must focus on profit and losses due to inflation. (Taylor, 2008) Considering the shipping sector, as part of the global economy and shipping companies, inflation often leaves the shipowner exposed to its negative effects (Stopford, 2009). Shipping companies monitoring inflation whilst adapting their strategies is imperative to mitigate its impact.

2.3 Strategies for Mitigating Risks

The maritime sector has proven to be resilient and adaptable when unexpected events occur, but that is the result of all factors' coordinated work in the backstage of shipping.

There are proactive and reactive measures that can be taken to prevent disruptions or minimize its effects.

In this paper, Strategies are divided into two categories; *Proactive* and *Reactive*. As *Proactive* are denoted the strategies implemented by the shipping company (they may be applicable to the ship as well) with the prospect of anticipating, preventing, avoiding and reducing risks, and foreseeing potential challenges. It includes the preventive measures, schemes, and strategies implemented with the aim of addressing the challenges before they occur with the scope to mitigate risks. As *reactive* strategies, are the measures and actions taken, and the strategies followed upon the emergence of a risk, in reaction to events with the scope of mitigating its consequences and halting its negative impact.

2.3.1 Proactive Measures & Strategies

2.3.1.1 Regulatory Compliance

It has long been argued that maritime safety can be promoted through the development of international regulations which will be adopted by shipping nations. It is imperative that shipping adheres to and complies with the regulations, created with the scope of avoiding accidents, enhancing safety and providing guidelines for shipping-related activities and operations. With the wide range of these regulations covering maritime risk management, ship safety, training, certification of crew, inspection and maintenance, contingency planning and environmental protection, and their scope being the creation of frameworks, they ultimately serve as precautionary measures to help prevent maritime accidents and poor operating practices. The application of safe working practices as required by the International Safety Management (ISM) and the International Convention for the Safety of Life at Sea (SOLAS) codes and by adhering to mitigation procedures as mentioned in the company's SMS, assist in avoiding hazardous situations.

International Maritime Organization (IMO)

The International Maritime Organization (IMO), established in 1948, serves as the global authority for setting standards in international shipping concerning safety, security, and environmental performance. Its core mission encompasses the development of regulatory frameworks, guidelines, and standards that govern various aspects of maritime operations, including ship design, construction, and equipment. Additionally, the IMO formulates international collision regulations, establishes global standards for seafarers, and creates conventions related to search and rescue, maritime traffic facilitation, and the transport of hazardous materials. This comprehensive regulatory work is further supported by several specialized Sub-Committees, ensuring the effective implementation of these standards across the global maritime industry.(IMO, 2019).

The Maritime Safety Committee (MSC) serves as the senior technical body for the IMO, focusing on maritime safety and maritime security of passenger ships and all types of cargo ships. Its responsibilities include revision of the SOLAS and related regulations, such as those on dangerous goods, life-saving equipment and fire-fighting systems. MSC's diverse agenda addresses challenges such as goal-based standards, autonomous ships, piracy and armed robbery against ships, cybersecurity, electronic navigation and the modernization of the Global Maritime Distress and Safety System (GMDSS). The MSC also addresses human factors issues, including amendments to the STCW Convention on the Training and Certification of Seafarers. (IMO, 2019).

The International Convention for the Prevention of Pollution from Ships (MARPOL)

The International Convention for the Prevention of Pollution from Ships (MARPOL) sets regulations for the prevention of Pollution stemming from shipping activities.

The International Maritime Organization (IMO), initially dedicated its attention to maritime safety and navigation. In the 1960s the world became more aware of the spillage of oil into the oceans and seas as a result of poor operating practices or through accidents. One of the most significant oil pollution incidents was the Torrey Canyon disaster near the southwestern coast off of the United Kingdom in 1967. IMO then launched an ambitious programme targeted towards marine pollution prevention and response, as well as issues of liability and compensation. One important outcome was the adoption of the International Convention for the Prevention of Pollution from Ships, universally known as "MARPOL" in 1973 (Lim, 2017).

International Convention for the Safety of Life at Sea (SOLAS)

The International Convention for the Safety of Life at Sea (SOLAS) is considered a pivotal international treaty for the safety of merchant ships, initially adopted in 1914, following the Titanic tragedy. After 5 versions, the current version, referred to as *SOLAS 1974,* after undergoing numerous amendments and updates includes Articles that set out general obligations, amendment procedure and so on, followed by an Annex divided into 14 Chapters. It mandates the implementation of the International Safety Management (ISM) Code and emphasizes maritime security measures, including an alert system for all vessels. The Convention underscores the importance of operational safety, navigation services, and the obligation to assist those in distress, thereby enhancing overall maritime safety standards. It is worth noting that the Convention verified the master as the person responsible for necessary decisions for the security of the vessels. Abiding by the SOLAS convention's chapters safeguards the company and its personnel against errors, accidents or omissions that may evolve into disruptions caused by human error, technical issues and natural elements (IMO, 2019).

International Safety Management Code (ISM)

The International Safety Management Code (ISM) was created with the purpose of providing an international standard for the safe management and operation of ships and pollution prevention. The Code is based on general principles and objectives since ships operate under different conditions and no two shipowners or shipping companies are the same. For the Code to have a widespread application, it is expressed in broad terms, and depending on the level of management, shore-based or at sea, different levels of knowledge and awareness of the items outlined are required. The general principles and objectives dictate the *"assessment of all identified risks to one Company's ships, personnel and the environment and establishment of appropriate safeguards."* (IMO, 2019), a regulatory requirement, explicitly making the risk assessment conducting process a legal obligation.

Safety Management System (SMS)

A means for the companies to comply with the ISM Code is the introduction of a Safety Management System (SMS) conforming to the requirements of the ISM Code, in which the safe practices in ship operation and safe working environment are outlined. Furthermore, all risks related to its ships, personnel and the environment are identified and appropriate safeguards are established. The SMS promotes the continuous improvement of safety management skills of personnel onshore and onboard ships, as well as the effective preparation for emergencies related both to safety and environmental protection. Furthermore, following and maintaining an SMS enhances compliance.[9] As such, establishing a Safety Management System can strengthen the company's position against possible mistakes , mitigating risks that relate to human error.

HSQE Management System

A company's Health Safety Quality and Environment (HSQE) Management System promotes the company's control over activities and issues that affect, or may be affecting, the Health, Safety, Quality and the Environment. Built into a management framework, the activities that need to be controlled are identified based on the company's experience, guidance by Marine Industry organizations and the results of risk management cases within the company. It is a system which provides the proper framework, for a company and its personnel, necessary to manage risks, relating to its people, assets, reputation and protection of the environment within which the company operates. An HSQE Management System (HSQEMS) hosts the means to meet requirements of HSQE policy and even achieve continuous improvement, while mainly focusing on risk management processes.

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[9] Source: ClassNK's Brochure titled "Certification for ISM Code & ISPS Code Safety Management System & Ship Security Management System", ClassNK.

The Designated Person Ashore (DPA)

To be compliant with the ISM, companies often have to designate an individual, sufficiently trained and able, who will be responsible for ensuring the safety of operations of each of the company's vessels. The creation of the ISM required the role and the work of a Designated Person Ashore (DPA) within the company, with the primary responsibilities being summarized as being the link between the vessel's personnel and the company, monitoring safety aspects of the operation of the vessel and pollution prevention, ensuring that adequate resources are applied. Moreover, the DPA might undertake responsibilities ranging from reporting to the company, to organizing safety audits. The DPA, a key role for the implementation of the company's Safety management System, must ensure that the crew operates efficiently and in safety while staying compliant with the SMS. The role of the DPA requires around the clock availability as the direct link between the company and the crew, and has the responsibility of deploying the necessary resources to ensure the safety of the crew, cargo and vessel and the environment. (Global Maritime Consultants Group, n.d.)

The STCW Convention

The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) was adopted on July 7, 1978, and came into force on April 28, 1984. This convention, along with its significant revisions in 1995 and 2010, have been setting throughout the years the minimum standards for aspects relating to the Training, Certification and Watchkeeping for Seafarers that countries have to achieve, or even exceed. The significance of the STCW Convention lies in the fact that it was the first to set a minimum baseline, applicable on an international level, to aspects that would relate to the training, certification and watchkeeping of seafarers.

The STCW addressed inconsistencies in training and certification practices across different countries, that originated from different countries' establishing their own standards of training, certification and watchkeeping of officers and ratings, with no reference to other countries' practices. Consequently, by setting a baseline for these standards, the STCW has played a crucial role in harmonizing the maritime industry's approach to seafarer qualifications globally. (IMO, 2019).

The International Maritime Organization (IMO) has taken steps to ensure a consistent interpretation of the STCW Convention by offering clarifications and guidance to assist Parties in meeting their obligations under the Convention. Additionally, to aid instructors in developing training programs that align with STCW standards for seafarers, the IMO has created a series of model courses that outline recommended teaching syllabi and learning objectives. (IMO, 2023).

STCW Code Amendments

The STCW Code underwent significant revisions in 1995 and 2010 to enhance clarity and address emerging challenges in maritime training and certification. The 1995 Amendments introduced a two-part STCW Code, delineating mandatory (Part A) and recommended (Part B) standards for seagoing personnel, while requiring Parties to report on compliance measures. The 2010 Manila Amendments, effective January 1, 2012, further updated the Code to combat fraudulent practices, revise work and rest hours, and enhance training requirements for various maritime roles, including security training and environmental awareness. (IMO, 2019).

It is apparent that the regulatory bodies and organizations believe in the training of human resources. As already mentioned, the STCW code is one of the codes supporting the training and certification of seafarers. When companies and their personnel follow the STCW code it can act as a proactive measure against disruptions. More specifically, an adequately trained crew is better prepared, thus, less prone to errors and mistakes that can negatively affect the shipping operations, and assists in risk mitigation by minimizing man-made disruptions.

The ISPS Code

The International Ship and Port Facility Security Code (ISPS Code), established by the International Maritime Organization (IMO), aims to enhance the security of ships and port facilities in response to threats identified after the attacks of 9/11 in the United States" (IMO, 2020),

Implemented through Chapter XI-2 of the International Convention for the Safety of Life at Sea (SOLAS), it applies to ships on international voyages and their port facilities. The ISPS Code's objectives include fostering international cooperation in assessing security threats, defining roles and responsibilities for maritime security, ensuring effective information exchange, and providing methodologies for security assessments. Compliance with the ISPS Code is mandatory for the 148 Contracting Parties to SOLAS, ensuring that adequate security measures are in place for maritime operations. (IMO, 2020).

MLC

The “Maritime Labour Convention, 2006, as amended” (MLC, 2006) was adopted by the 94th (Maritime) Session of the International Labour Conference (ILC) in 2006 and is applicable and enforceable (based on flag State inspection and for port State control) to a vast range of ships operating on international and national or domestic voyages. Its scope is to address and protect the right of the seafarers’ and to ensure decent working conditions in almost the entirety of their working and living conditions, amongst them being the minimum age, employment agreements, hours of work and rest, repatriation, on board medical care, health and safety protection and accident prevention, etc. (International Labour Organization, 2024).

The Role of the Flag State

Flags have historical significance for shipping. In the past, as ships started leaving their domestic waters and venturing into international waters, flags were used as a way to identify ships and their nationhood.[10] The United Nations Convention on the Law of the Sea (UNCLOS), adopted in 1980, sets the "traditional rules for the uses of the oceans and at the same time introduces new legal concepts and regimes and addresses new concerns". Codified in international law by the 1958 High Seas Convention and later in the 1982 UNCLOS, flag states were granted the right to operate ships on the high seas, a right that was accompanied by responsibilities.[11]

UNCLOS specifies the duties of the Flag State. Specifically, the Flag State can exercise its jurisdiction and control in matters of administrative, technical and social nature over ships flying its flag. Also, for ships flying its flag, it has the responsibility of taking the necessary measures to ensure safety at sea concerning, among others, the construction, equipment and seaworthiness of ships. As per the UNCLOS, Flag States must ensure that ships must be surveyed by a qualified surveyor of ships, before their registration to the Flag and thereafter at appropriate intervals. Flag States apart from acting according to their obligations as laid out by the UNCLOS, have to also ensure that vessels flying their flag remain compliant with international rules and practices and the requirements of IMO Conventions, Codes and other instruments, as they navigate international waters. This includes enforcing safety standards, labor conditions, and environmental regulations to uphold maritime law and safety.[12]

Flag States' duties ultimately assist in maintaining compliance with international rules, regulations and practices for vessels sailing on the high seas flying its States' flag, as well as their enforcement.

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[10] Source
[11] Source
[12] 1, 2

2.3.1.2 Risk Assessment

As already mentioned earlier within this chapter Risk Assessment is the "overall process comprising a risk analysis and a risk evaluation" (*ISO 9001:2015(en), Quality Management Systems — Requirements*, 2014).

This is a process widely used to assess the risk of operations in which assets of the shipping company plans to engage in.

The scope is to analyze and evaluate the risks of the operation, as well as their mitigation. It is a proactive measure often required by international organizations, the company's SMS, clients and accrediting bodies. Furthermore, ship registries and Protection and Indemnity (P&I) clubs often provide guidelines for conducting Risk Assessments to assist their members in incorporating the Risk Assessment "ethnos".

The Formal Safety Assessment Process

In line with IMOs recommendations, the Formal Safety Assessment Process (FSA) is *a rational and systematic process for assessing the risks associated with shipping activities and assessing the costs and benefits of IMO's options to reduce these risks, with the aim of improving maritime safety and protecting life, health, the marine environment and property through risk analysis and cost-benefit assessment.* (IMO, 2018). IMO states that the FSA encourages compliance with maritime regulations and promotes safety and environmental protection. FSA is utilized to enhance decision making and is already being applied in bulk carrier safety. It is also a proactive measure, in contrast to previous reactive regulatory approaches, facilitating the identification and consideration of potential hazards prior to the occurrence of an accident.

An FSA includes (i) *the identification of hazards* during which the relevant accident scenarios with potential causes and outcomes must be listed,(ii) *assessment of risks* where the risk factors are evaluated, (iii) *risk control options,* or the formulation of regulatory measures for the control, and reduction of risks that have been identified, (iv) for each risk control option, the determination of cost effectiveness, or *cost-benefit analysis,* and (v) *recommendations for decision-making*, providing information on the hazards and their risks, as well as the cost effectiveness of the provided alternative options for risk control. (IMO, 2019)

To simplify, the Formal Safety Assessment asks the following questions:

(i) What could go wrong? to identify the hazards,

(ii) How bad and how likely? to assess the risks,

(iii) Can matters be improved? to introduce risk control options,

(iv) What would the risk control options cost and how much better would it be? to determine the cost effectiveness of each risk control option, and

(v) What are the actions that we should take? making recommendations to assist the decision-making (IMO, 2019).

To understand and highlight the importance of Risk Assessments for shipping operations, Chapter 4 is dedicated to the Risk Assessment concerning a real-life case using data and procedures provided by an esteemed shipping company.

2.3.1.3 Contingency Planning & Sustainability

Contingency planning and sustainability are imperative for achieving effective risk management. Both can assist in minimizing the impact of risks and uncertainties. They are beneficial to long-term resilience, the effective management of reputation and compliance with regulations. Risk Identification and Assessment, Response Strategies, Business Continuity and Sustainability comprise “Contingency Planning”. In the realm of shipping, the timely identification of potential risks and assessment of their impact, and at the same time, the construction of response strategies, are beneficial in the preparedness against unforeseen events.

Response strategies outline the procedures, communication aspects, allocation of resources and promote the overall coordination between stakeholders and authorities.

Business continuity argues that having backup systems, alternative routes, emergency protocols etc. in place, can assist the company in remaining operational, providing its services amidst various challenges. Business continuity promotes a company's resilience and thus, can mitigate risks.

Economic, social and environmental *sustainability* and their diligent practice promotes long-term resilience. Introducing such practices into operations can reduce the exposure to risks stemming from insufficient resources, climate change and changes in regulations.

Furthermore, sustainability practices and initiatives may become a competitive advantage against a competitor who might not be practicing sustainability. It can enhance the reputation of the company and build trust across the stakeholders, attract new clients and strengthen the relationships with existing clients, investors or other parties (i.e. governments). Sustainability also helps companies stay compliant with regulations, avoiding non-compliance related risks. By applying industry standards and proactively responding to environmental and social issues, penalties, risks of sanctions as well as legal risks can also be reduced.

2.3.1.4 Collaboration and information sharing among stakeholders

Shipping is ever-evolving and access to information is of imperative importance in order to assess available data successfully and make decisions. This can be achieved through collaboration and information sharing.

Stakeholders can collaborate and exchange information efficiently to work together towards a mutually beneficial outcome. Information sharing can be achieved using *technology* (such as vessel tracking platforms, automatic identification system "*AIS",* blockchain technology), by *participating in schemes* such as the Voluntary Community Reporting (*VCR*). Moreover, it is achieved through *organizations* that have been established with the scope of providing information and guidance on compliance, such as the IMO, as well as *regulatory frameworks*, such as the ISPS Code for maritime security, requiring the collaboration and information sharing between stakeholders.

Information sharing and collaboration can be done on an ad hoc basis between stakeholders. A structured approach of collaboration and information sharing could mean forming partnerships and alliances with other stakeholders such as other shipping companies, port authorities, government agencies and technology providers and the exchange of valuable data, insights, create communication channels, create synergies and allocate responsibilities. Safety, security and efficiency benefit from collaboration and information sharing, as stakeholders have the chance to improve their operational performance, their safety standards across the shipping sector and, finally, mitigate risks safety and security risks, operational risks, navigational risks, environmental risks and compliance risks. By sharing information that could be related to these risks, an effective management of disruptions can be achieved.

Concerning safety, information sharing, data exchange and collaboration can improve situational awareness,and allow for better decision making. It can be beneficial in reducing the probability of a navigation accident occurring, for example due to adverse weather conditions, grounding, or collision, potentially leading to loss of property, casualties or environmental accidents.
Enhancing Security, information and collaboration facilitate the identification of potential security threats and the implementation of proactive measures of risk mitigation. For example, sharing intelligence on piracy, terrorism or other security risks in the area, can safeguard the vessel against security breaches and criminal activities.

Distribution of information can provide valuable insight and promote decision making, optimizing and streamlining procedures and operations, mitigating risks stemming from delays, losses and inefficiencies. Environmental data and risk assessments can assist stakeholders in addressing environmental issues such as oil spills, pollution and ecosystem damage. By distributing information on environmental regulations, best practices and response procedures, stakeholders could work towards reducing the impact and numbers of such incidents.

Information sharing among stakeholders such as ship operators, port facilities, and governments, can provide useful information on regulatory requirements and industry standards. Stakeholders can demonstrate their compliance with them, by providing information such as documentation, certificates, reports, and minimizing the risk of non-compliance.

2.3.1.5 Buffer Time Allocation

To mitigate the risks related to additional time spent in port due to unplanned events allocating a time buffer during the designing of a ship's schedule/timetable, can reduce the consequences coming from an uncertain or changing schedule. Since the buffer time is planned, and it is considered in advance, it is compatible with the reactive strategies category This strategy reduces the port time uncertainty and operational costs, as the schedule remains more flexible allowing for a window within which, the shipping company has the opportunity to perform recovery actions and reduce the impact of any delays or unforeseen events at transport nodes (i.e.sea ports). This strategy is widely utilized by container shipping companies for ships deviating from the original schedule (Elmi et al., 2022).

2.3.1.6 Contractual Agreements

Legally enforceable contractual agreements are utilized in shipping, to specify what the parties entering into them should be doing or should refrain from doing. Depending on the scope of the agreement parties involved could be shipowners, manager companies, individuals (i.e. crew), etc. Agreements cover a wide spectrum of shipping activities and commercial transactions, such as chartering, shipbuilding, transportation of goods, crewing, management, provision of services. Contracts outline the obligations, liabilities and duties and can contribute to disruption management and risk mitigation as they can help avoid uncertainties, understand and allocate responsibilities, share risks, mandate insurance coverage and requirements, provide mechanisms for dispute resolution and promote compliance with regulations. Contracts can assist each party in understanding the responsibilities and avoiding disputes or misunderstandings that could potentially introduce risks.

BIMCO Standard Forms

The Baltic and International Maritime Council (BIMCO), known for its standardized contracts and agreements, known as “BIMCO Standard Forms”, offers a range of widely used forms that facilitate various shipping activities. These documents, including the 'TIME' Charterparty Forms ('BALTIME', 'SUPPLYTIME'), 'GENCON 2022' for dry bulk, 'TANKERVOY 87' for tankers, and 'SHIPMAN 2024' for crew and management, are designed to cover essential commercial and legal aspects of shipping agreements. Additionally, 'CREWMAN' contracts appoint crew managers, while the 'LINEWAYBILL' serves as a non-negotiable template for liner sea transport. BIMCO’s standardized forms[13], aim to mitigate risks in commercial exchanges, ensuring legally enforceable agreements that foster robust relationships and provide safeguards against unforeseen circumstances.

Charter Party

The charter party defines the obligations and rights of the parties that enter them and regulates the commercial and legal relationship between them. It is a contract in written form that contains the conditions, the obligations of the parties, in particular the shipowner or carrier and the charterer or shipper, as well as the costs and earnings, amongst other things. (Voudouris & Plomaritou, 2020).

P&I insurance

Through Protection and Indemnity (P&I) Clubs, shipowners can merge their insurance premiums and if a claim is raised, it is paid on a mutual basis. P&I Insurances, mandatory for all shipowners whose vessels are used for business or transportation (passenger, cargo, workers) across international areas. It is a policy that covers liabilities including loss of life, injury of person onboard, cargo loss or damage, pollution, collision, damage to property. Additional policies could be added that will cover specific risks or events. P&I Insurance is a policy with which shipowners can reduce risks due to extreme financial costs, and even legal repercussions.

[13] Context on BIMCO contracts is sourced from BIMCO’s website.

2.3.2 Reactive Strategies for Risk Mitigation and Disruption Management.

At the face of an emerging disruptive event, reactive strategies can be implemented to regain control over a situation and mitigate risks.

2.3.2.1 Ship Schedule Recovery Strategies

A ship's deviation from schedule is a phenomenon called *service or schedule unreliability* (Xiangtong & Dongping Song, 2016). Adherence to the agreed timelines & schedules is a very significant characteristic of shipping, and delays should be avoided since they can create additional costs, and damage reputation. Elmi et al. view the ship schedule recovery problem as an operational-level, real-time decision problem, which is compatible with the Reactive Strategies that need to be applied to rectify it.

(a) Ship Sailing Speed Adjustment

Literature names the increase of the sailing speed to offset any delays that have caused the ship to deviate from the original schedule as another commonly adopted recovery strategy. *Ship Sailing Speed Adjustment* is a strategy utilized by shipping companies to compensate for any delays that emerge - for example disruptions to the ship's original schedule due to unavailability of port service operations, bad weather etc). A ship arriving late could have financial and reputational consequences for the shipping company. This strategy could mitigate the risks that arise from delays but it leads to increased fuel consumption and fuel cost, as the vessel speeds up (Mulder & Dekker, 2019, Chung-Yee et al., 2015).

In *Fig. 2.1*, Elmi et al. present in a visual example where the Sailing Speed Adjustment strategy is applied to liner shipping. In this instance, the ship's shipping route starts from Port 1 to Port 4, and circles back to Port 1 (Port 1 sailing to Port 2 sailing to Port 3 sailing to Port 4 sailing to Port 1 etc.). In *Fig 2.1* the ship increases her speed from 23 knots to 24 knots to compensate for the longer transit time from Port 3 to Port 4 due to some disruption that caused delay. It can be observed that with the new speed the ship manages to reach Port 4 at the appropriate time. (Elmi et al., 2022)

(b) Handling Rate Adjustment (Liner Shipping)

Elmi et al. present the Handling Rate Adjustment for liner shipping as an effective reactive strategy to compensate for lost time caused by unexpected delays as a consequence of a disruptive event. As observed in *Fig. 2.1* example b, the ship arrived late at Port 2 due to a disruptive event that occurred between Port 1 and Port 2. The shipping company may request from the port operators a handling rate which promotes higher handling productivity (compared to the one originally agreed). With the new rate, the delay could be rectified, since the ship would be able to leave Port 2 at appropriate time and sail to Port 3 as per the original schedule. The above is applied accepting that there will be additional port handling costs and given that the capacity of the terminal operators to support higher handling rates (equipment, workers etc.) is available (Elmi et al., 2022). Additionally, Mulder & Dekker support that increasing the handling capacity can mitigate the financial risk for the shipping company. (Mulder & Dekker, 2019)

(c) Port Skipping (Liner Shipping)

The bypassing of a port or a string of ports previously included in the ship's original schedule is a commonly used reactive strategy applied by shipping companies, to offset large delays (Elmi et al., 2022), a strategy known as *Port Skipping*.*Marine Traffic*'s Papaspyros L. names some circumstances that could lead to the shipping company to apply the port skipping strategy, as a reaction to insufficient demand, port congestion, extreme weather conditions, strict schedule, new global regulations, need for urgent ship repairs, local holidays and strikes Periods of global economic recessions, trade imbalances and ship overcapacity lower the container demand, and shipping companies find it necessary to make their operations more cost effective by deciding that their ships will skip ports (for example, ports in which only a few containers would be loaded), in an attempt to mitigate the financial risks emerging due to higher costs. (Papaspyros, 2023).

Another reason for port skipping is port congestion due to ships waiting to enter the port or larger ships calling the port, strikes, port services issues (i.e. poor port infrastructure, increased volume of container traffic, slow customs procedures), political events. As a consequence there can be delays in loading/unloading operations as well as the ship's departure and the ship is at risk of losing its ETA and/or deviating from its original schedule. To make up for the delays and stay consistent with the rest of the ship's sailing schedule, some ports originally included in the sailing schedule may have to be canceled. To mitigate the risks emerging from sailing through areas where extreme weather conditions are present (i.e. heavy rains and strong winds) and navigation will be dangerous, the decision to skip port can be vital for the crew, cargo and ship. Also, extreme weather, such as storms, may damage port facilities that forbid the vessel from calling that port. New global regulations have the potential to disrupt the ship's operation and schedule, for instance, crew may be obliged to stay quarantined when calling a port of a country which causes disruption if not accounted for during the planning phase of the schedule Urgent ship repairs, where a ship may even need to remain in dry dock for numerous days, and local holidays or strikes that disrupt port operations, are two more reasons for port skipping to avoid the risk of delays or disruption. (Papaspyros, 2023).

To summarize, the port skipping strategy can be applied when facing financial, man-made, natural, and technical disruptions.

As observed in *Fig. 2.1* example **c**, (Elmi et al., 2022) port skipping is applied to compensate for the disruption in Port 4, which could be any of the aforementioned. To recover the schedule, the ship skips Port 4 and heads straight from Port 3 to Port 1.

(d) Port Skipping with Container Diversion (Liner Shipping)

Shipping companies implement the strategy of *Port Skipping with Container Diversion* (*Fig 2.1* example d)*,* for the same schedule recovery reasons as Port Skipping. The difference with this reactive strategy, as per Elmi et al, is it creates additional costs for the shipping company, the inland transport must be planned and executed, and the adequate container terminal capacity of the port that will handle the diverted containers must be ensured. The upside is that when implementing the Port Skipping with Container Diversion, the recipients will receive their containers and the ship will load the Port 4 containers, as opposed to implementing the Port Skipping strategy. As Port 4 was facing a disruption, the ship was ordered to skip it and to proceed directly from Port 3 to Port 1. The import containers will be offloaded at Port 1, while they were intended to be offloaded at Port 4, and then will be diverted to intended recipients via the intermodal network. Similarly, the export containers will be diverted to Port 1 via the intermodal network, whilst they were originally scheduled to be loaded at Port 4(Elmi et al., 2022).

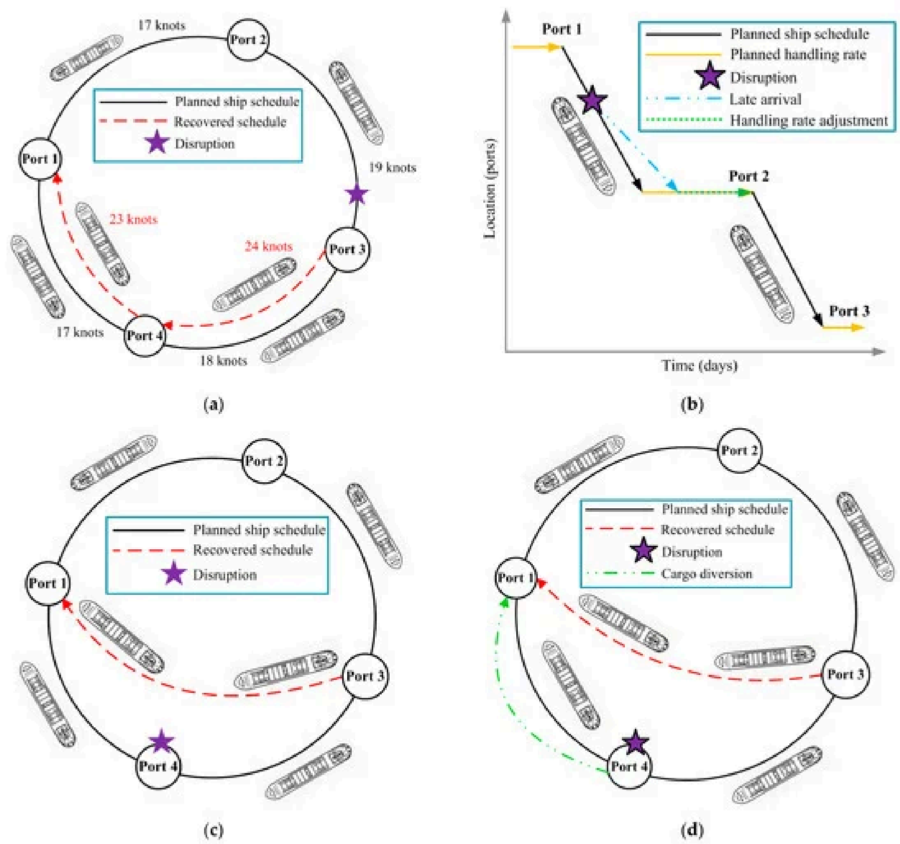

Fig. 2.1 Elmi et al.'s illustrative example of Ship Schedule Recovery Options, as applied to Liner Shipping: **(a)** sailing speed adjustment; **(b)** handling rate adjustment; **(c)** port skipping; and **(d)** port skipping and container diversion. (Elmi et al., 2022)

2.3.2.2 Rerouting

Rerouting can be considered a reactive strategy as it describes the changing of the ship's original route to avoid or mitigate a risk. Shipping companies opt for the most cost-effective and efficient route for their vessels and the decision to change them is taken in order to adapt to events, such as unfavorable weather conditions, the ship having to undergo urgent repairs, needing to receive bunkers, or to avoid disruptions such as strikes or risks due hostilities possibly stemming from political instability, etc.). Adjusting service routes can be an ad-hoc strategic decision often made by liner carriers. They strategically approach it by occasionally proceeding to the addition or removal of a port or reviewing the sequence of the ports that will be visited. As liner shipping operates on fixed schedules that are published in advance for clients' perusal, the drawback is that when schedule reviews (port swapping) happen frequently, it could have a negative impact on the company's service reliability and reputation (Asghari et al., 2023).

2.3.2.3 Port Swapping

This "*advanced*" Ship Schedule Recovery strategy of Port Swapping (Brouer et al., 2013) is described as the situation when a ship's ports of call order changes. In some instances it is seen as impractical or inefficient, such as when a vessel has a fixed order of calls or has scheduled loading and unloading operations, it is a strategy to apply when the schedule of the ship must be recovered after encountering disruptions and delays (Asghari et al., 2023).

2.3.2.4 Slow Steaming

Slow steaming has been widely adopted by shipping companies as a measure to mitigate the monetary risks that originate from increased operational costs. Provided that the ship's schedule can support it as, according to the study by Lee et al., slow steaming can have certain drawbacks which are the increased sailing time and unpredictability during the voyage (Lee et al., 2015) shipping companies can implement this strategy and reduce the sailing speed and consequently the fuel consumption costs (Elmi et al., 2022).

2.3.2.5 Inventory Management

To ensure continuity of operations, efficient inventory management is of imperative importance. The performance of ship inventory management can ensure that critical items are available if needed, the downtime and costs associated with shortages can be reduced, and it can assist in storage space optimization onboard the ship (SERTICA, 2023).

Safety Critical Equipment and Safety Critical Spare Parts

On a vessel, any single component failing, possibly leading to a hazardous situation or accident is called a "*Single Point Failure*". Such risk of failure stems from mis-operation, lack of planned maintenance, inherent vessel design, incorrect installation, electrical failure, fire, flood or even unpredictable circumstances. Identifying safety critical equipment and assessing the need for additional safety critical spare parts, and establishing procedures around their maintenance and carriage respectively, or even back-up systems, promotes effective risk management (OCIMF, 2018).

Critical Equipment

ISM Code states that the company has to establish formal procedure to compile a list with equipment and technical systems that if sudden operational failure occurs of which, it may result in hazardous situations. The Company's Safety Management System should "*provide for specific measures aimed at promoting the reliability of such equipment or systems"* such as *"regular testing of stand-by arrangements and equipment or technical systems that are not in continuous use"*[14].

To create a list with the critical spare equipment, ISM Code recommends that the company needs to identify the shipboard operations vital to safety and to the protection of the environment, assess the risks, especially during critical shipboard operations, and conduct a root cause analysis in the way of near-miss/accident investigation. After identification, there is the need to establish safeguards to ensure functional reliability or the use of back-up arrangements

[14] ISM-Circular 01-2008, Sub.: Guidance on ISM Code section 10.3 "Identification of Critical Equipment"

Safety Critical Spare Parts

The spare components related to the maintenance and repair of safety critical equipment are called Safety Critical Spare Parts.

Maintaining inventory of critical spare parts onboard the vessel can be used both proactively and reactively, and their use can prevent or help recovering from hazardous situations. Proactively, safety critical spare parts can be used to reduce the risk of hazardous situations, such as preventing critical equipment from failing by carrying out planned maintenance. Reactively, when a safety critical equipment has been damaged, a safety critical spare part can be used to repair it, preventing the hazardous situation from escalating (OCIMF, 2018).

2.3.3 Other Mitigation Strategies

Militation strategies in container shipping were identified and ranked from most effective to least using the data of responses authors Chang, C et. collected via questionnaire survey. The results showed the top six strategies being “the formation of alliances with other shipping companies", “the usage of more advance infrastructures (hardware and software”, “the more careful selection of partners” , “entering into long-term contracts with shippers”, “collaborating with partners (e.g. port operators, inland transportation operators) through the construction of long-term plans”, “the design of flexing timetable-schedules”, and last being “the acquirement and merging with other shipping companies¨. These strategies’ relative importance was reviewed against three criteria: reducing financial loss, reducing reputation loss and reducing safety and security incident-related loss (Chung-Yee et al., 2015).

2.4 Technologies for Disruption Management

It can be argued that technologies for disruption management within the maritime field have been maturing the last 25 years, significantly contributing to the operational efficiency, safety as well as the environmental sustainability of operations.

2.4.1 Real-Time Tracking and Tracing

Shipping utilizes real-time tracking and tracing systems to facilitate the availability of information and increase visibility within the supply chain which mitigates risks that relate to increased costs, security and safety aspects, and enhance efficiency. Such systems also promote a more customer-centric relationship between the business and the client, who have immediate access to information concerning the shipment.

To avoid traffic and congestion real-time tracking is utilized to optimize routes and choose better paths, increasing efficiency while reducing costs. Moreover such systems may generate early warnings, due to weather, traffic, or other unforeseen events causing potential disruptions, helping companies in their management and minimization of their impact.

2.4.1.1 Global Positioning System (GPS)

The Global Positioning System (GPS) is a very significant technology for the navigation and safety at sea. It provides information on a ship's position, course and speed. With this highly accurate information the exact location can be determined, which assists in planning and following a safe route through adverse weather conditions, avoiding risks.[15] Furthermore, with this valuable information on the real-time location of ships and cargo, stakeholders are able to monitor the location of shipments, improving the route optimization and achieving timely deliveries.

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[15] Source

2.4.1.2 Automated Identification Systems (AIS)

Since 2000 and after addressing the need for standardization and collaboration across organizations, Automated Identification Systems (AIS) is being used[16] to this date, enhancing the safety of life at sea and promoting safe and efficient navigation. According to IMO the purpose of AIS is to assist in the identification of ships, target tracking, search and rescue operations, situation awareness and to simplify the exchange of information, due to the SOLAS regulation V/19 requiring the exchange of data ship-to-ship and with shore-based facilities via AIS. Quality of information available to the Officer On Watch is improved by data received via AIS, as it can provide useful supplementary information to those deriving from navigational systems (including radar), while either while at a shore surveillance station or on board a ship. (IMO, 2015).

2.4.1.3 Electronic Chart Display and Information System (ECDIS)

The Electronic Chart Display and Information System (ECDIS) revolutionized navigational safety, offering reliable information and valuable functionalities and aiming to reduce navigational workload. After decades of paper nautical charts, in 2011, following the relevant SOLAS amendment, it was made mandatory for all ships engaging in international voyages to use the IMO-compliant ECDIS, with an implementation period from 2012 to 2018. ECDIS implementation required specific performance standards areas depending on the type of the ship to which it would be installed. ECDIS can interface with other interfaces such as the radar, Navtex, and Automatic Identification Systems (AIS). Contributing to navigational safety, ECDIS displays information from Electronic Navigational Charts (ENC), position information and navigational safety information, and can generate audible and visual alarms when it estimates the ship might encounter hazards. (Mattheou & Skempes, 2022)

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[16] As per IMO, there might be some exceptions concerning the carrying or usage of AIS: "*specific ship types (e.g. warships, naval auxiliaries and ships owned/operated by Governments) are not required to be fitted with AIS. Also, small ships (e.g. leisure craft, fishing boats) and certain other ships may be exempt from carrying AIS. Moreover, ships fitted with AIS might have the equipment switched off*". (IMO, 2015)

2.4.1.4 Radio Frequency Identification (RFID)

Radio Frequency Identification (RFID) technology can assist in the tracking of goods and shipping containers, when in transport or in warehouses promoting visibility and warehouse management assisting in reducing costs. Furthermore, frequently, containers can become lost upon their arrival at a warehouse, and the items they contain can be stolen.

With RFID it is possible for a company to verify that the items placed in the containers are indeed the items included in the accompanying documentation of the shipment, as well as their location. Similarly the containers themselves can be tracked, which is accomplished by reading the tags by using a handheld interrogator, or by installing a portal around the shipping bay - it is necessary that the goods have been previously properly staged.

An active tag that identifies a particular container, possibly having a GPS transmitter in it, can provide information on its location via satellite or the cellular network and information on its contents. Furthermore, active tags with sensors are able to report if the container's door has been breached.

Using RFID technology in shipping, apart from tracking the movement of containers and their goods and providing information on their location and contents, can assist in reducing theft, as well as the risk of terrorism. (Roberti, 2024)

2.4.1.5 The Internet of Things (IoT)

Connectivity, data collection and tracking, has been benefited by the integration of IoT devices in maritime operations. The Internet of Things is a network with wired and wireless connections, which comprises physical devices and objects that share and collect data with minimal human intervention. Data collected from these devices is used for data analytics and to drive services and applications of the IoT environment. In shipping such data is used to provide insights and help optimize routes and predict maintenance.

Through IoT sensors, real-time monitoring of ships, cargo and its condition, equipment, the tracking of shipments is achieved, even in remote areas or globally, providing information on the speed and location, as well as alert operators to potential issues that may emerge and cause disruptions. IoT is assisting in improving efficiency, reducing operational cost and enhancing customer satisfaction (Inbound Logistics, 2024).

Moreover, OECD in its 2017 International Transportation Forum (ITF) report on Information Sharing for Efficient Maritime Logistics, stated that as autonomous ships and the implementation of e-navigation in commercial shipping are getting closer, maritime IoT applications are evaluated as having the potential to promote efficiency and coordination, assisting in the management of technical and operational aspects of complex transport and supply chain systems. Connecting physical objects, facilitating communication between sensor application and people, along with the support of an ecosystem and other technologies, such as RFID, the IoT “has the potential to significantly improve navigation, safety, remote monitoring and maintenance, and maintenance, communication and environmental efficiency” (OECD, 2018).

2.4.2 Analytics and Machine Learning

Artificial Intelligence (AI) and Machine Learning (ML)

Artificial Intelligence (AI) and Machine Learning (ML) technologies can provide predictive insights, improve the decision-making processes and increase efficiency, minimizing delays, costs, and risks.

AI can enhance supply chain visibility, assist in forecasting and planning, manage inventory, identify shipping delays, track cargo, and predict bottlenecks.

In the context of maritime risk management, these technologies can process and analyze data and predict disruptions, optimize routes, support cargo handling operations, maintenance, promote environmentally sustainable practices and reduce risks associated with operational disruptions (Inbound Logistics, 2024).

ML and AI technologies can also identify safety hazards, predict collisions through the analysis of data relating to the vessel's behavior, navigational data and weather patterns. Through data collection from maritime operations and their analysis by using machine learning algorithms one can extract insights to enhance decision-making, and improve operational and safety aspects such as routing, predict maintenance, and improve efficiency. Finally, these technologies also enable the development of autonomous shipping (Spire Global, 2024).

Digital Twin Technology in Predictive Analytics

Predictive Analytics

Predictive analytics is a crucial aspect of data analytics that focuses on forecasting future trends and events by utilizing historical data. This practice enables businesses to strategize effectively and make informed decisions by answering the question, "What might happen in the future?" In the shipping industry, predictive analytics can be employed to anticipate various scenarios, such as potential machinery malfunctions or fluctuations in cash flows. By leveraging machine-learning algorithms or manual analysis, shipping companies can utilize predictive insights to enhance operational efficiency, optimize maintenance schedules, and improve financial planning, ultimately driving strategic growth and minimizing risks. (Cote, 2021)

Digital Twin Technology

The Digital Twin technology allows companies to simulate scenarios, predicting various disruptions and can be used for proactive planning and to prevent escalation of hazardous events.

It is necessary the digital twin to be an exact replica of the physical object, secondly, the digital twin's connection to an existing object -contradictory to models that can exist independently- and lastly, the digital twin must be based on data from the real-world counterpart through sensors and Internet of Things (IoT) devices[17], that describes the object and changes over time. (Hapag-Lloyd, 2024)

According to Hapag-Lloyd, embracing new technologies such as the digital twins technology has the potential to update the landscape of the shipping and logistics industry to a more connected, resilient and agile version. Digital twins technology can enhance maritime risk management, providing understandability, increasing efficiency and minimizing potential risk. Via virtual replication, real-time data analytics, and predictive modeling, digital twins technology can help one understand the available options, by using input sectors of the digital twin of the ship, to measure the behavior of the (physical) ship when encounering environmental factors such as waves, currents, wind and temperatures. Digital twin technology can also facilitate risk management and proactive maintenance as it can help minimize equipment failures, accidents and environmental impacts, enhancing safety and compliance. Furthermore, it can reduce environmental impact, helping the company to align with sustainability and eco-efficiency goals, by optimizing fuel consumption, route planning and resources allocation.Furthermore, digital twin technology can use real-time sensor data relating to ship's components and predict failures or assist in the scheduling proactive repairs, reducing risks and costs relating to performance. Finally, this technology can also enhance resilience and responsiveness, mitigating risks and reducing costs by providing real-time visibility into inventory levels, routes, delivery timelines, and identifying bottlenecks (Hapag-Lloyd, 2024).

[17] Source

2.4.3 Blockchain Technology

Blockchain Technology can be used in shipping to enhance the transparency, security and efficiency of the tracking system, and ensure data is accurate and tamper-proof, through an immutable ledger of transactions and movements, building trust among stakeholders.
It is a technology that can be implemented in a wide range of shipping activities such as in warehouse management, increasing transparency and efficiency in tracking the items and documents, while reducing paperwork, delays and human error. For shipments, blockchain technology can be used to provide full control to the shipper, while each involved party has access only to data relevant to their role. This enhances security, mitigating the risk of fraud, whilst reducing paperwork and simplifying the shipping process. Blockchain technology can be also implemented in customs, insurance and payments and simplify the necessary procedures, while reducing costs, labor, risks, safeguarding stakeholders against fraud and manipulation.
(Det Norske Veritas (DNV), 2018)

2.4.4 Satellite Communications

Since the adoption of Satellite communications in the 1970s global coverage in telecommunications has been improved, enabling the real-time exchange of data between ships and shore, such as weather updates, positioning, navigation, and tracking of vessels (e.g. GPS) , communication in cases of emergencies (e.g. Global Maritime Distress and Safety System (GMDSS) and remote diagnostic and maintenance[18]

2.4.5 Cyber-Security Enhancements

Due to the rise of digitalization, Cyber-Security has become a critical aspect of risk management, as with the increasing growth and reliance on digital technology and services, the ship and company can be exposed to cyber risks. This highlights the importance of enhancing cyber-security and cyber risk management practices, personnel’s relevant training and skill building, as well as establishing management systems and recovery plans to address cyber

[18] Source

security issues and safeguard shipping from current and emerging cyberthreats and vulnerabilities.

IMO has issued guidelines on maritime cyber risk management to support safe and secure shipping, and build its resilience against cyber-attacks, which can be incorporated into existing risk management processes. (IMO, 2019)

Members of the shipping community have been addressing the cybersecurity threats and protective measures, such as the ICS who has provided guidelines on cybersecurity onboard ships, aiming for the protection of the ships' OT (i.e. ECDIS), and IT systems (i.e. Clients), and recommends risk assessments, actions/responses, sets responsibilities, and recovery plans and tools. (International Chamber of Shipping, 2021).

Enhanced cybersecurity measures, including advanced firewalls and antivirus systems, the segregation of OT from IT systems and employees' cyber-security awareness, training and skills, can protect assets against cyber-attacks that could disrupt shipping operations. (Wingrove, 2024)

Chapter 3: Disruption Cases In the Shipping Industry

3.1 Impactful Disruptions in the Shipping industry

To provide perspective on the impact disruptions of various nature can have on shipping, nine recent disruption cases are presented.

1. **Hanjin Shipping Bankruptcy [2016] - *(Case 1)***

In 2016, the bankruptcy of Hanjin Shipping, at the time the number one ocean carrier of South Korea and once number six in the global container shipping industry[19], represented a significant disruption on the global logistics landscape due to its vessel operating size and its joint operations within an alliance with China Ocean Shipping Company (COSCO), K-Line, Yang Ming and Evergreen[20], as services were interrupted without notice. The collapse resulted in ships remaining stranded at sea with their cargo undelivered, ports refusing entry to ships due to fears of insolvency, and delays of goods. Competitors raced to leverage this event, offering additional services to the market. Furthermore, the collapse led to an increase in rates due to the increased demand on routes and ports previously serviced by Hanjin. On the other hand, shippers had to face increased costs and uncertainty as they now had to find and cooperate with alternative carriers. Additionally, Hanjin was a stakeholder in 20 container terminals with a total annual capacity of 22.4 mil. TEU, and its collapse mainly affected Korea, who faced the most significant potential terminal capacity disruptions. With the collapse, terminals lost ship calls from Hanjin, an event that negatively affected their revenue. Consequently, these assets were sold to other terminal operating companies such as the Mediterranean Shipping Company (MSC) and Hyundai Merchant Marine (HMM).[21] Uncertainty prevailed in international shipping following Hanjin's collapse which led to the establishment of financial safeguards to prevent similar collapses of carriers in the future (Pauli & Wolf, 2017).

[19] Source
[20] Source
[21] Source

It could be argued that a strong industry player's collapse due to financial vulnerabilities is capable of triggering ripple effects felt across the industry, highlighting its dynamism and the consequences instability and uncertainty can have in the industry.

2. Cyber-Attack on Maersk [2017] - *(Case 2)*

Along with the increasing dependance of shipping in digital technology and digitization, the exposure to potential cyber-attacks also increases. This has become a growing concern for the industry. In the past, cases of cyber-attacks on shipping companies have caused disruptions of operations and brought security issues to attention, highlighting the need for the industry to adopt cybersecurity measures for its protection.

In 2017, the NotPetya ransomware[22] global attack on Maersk caused widespread operational disruptions and financial losses of millions of dollars, after the ransomware infection impacted most of their key systems, disrupting every function critical to the organization's survival. (LRQA Nettitude, 2020). The attack-related costs for Maersk from this ransomware attack, excluding customer reimbursements for the expense of rerouting or storing cargo, was estimated at $250-300 mln. The attack first struck Maersk in its Ukrainian offices and eventually infected 45,000 PCs and 4,000 servers as well as the shipping giant's facilities, with 17 out of Maersk's 76 global port terminals being shut down. Additionally, the company was unable to receive new bookings, given the fact that its shipping booking tools had been affected, disrupting the company's main sources of revenue. Even Though the attack did not affect the company's ships, the terminal's software which prior to the attack, received Electronic Data Interchange (EDI) files from ships, now paralyzed, resulted in Maersk's ports having no information on the container's contents and unable to perform the loading and unloading of containers. Consequently, operations were halted for days, until the company resulted in its employees using

[22] "**Ransomware** is a form of 'malware', maliciously-created computer software designed to stealthily infiltrate PCs, mobile devices, and even Industrial Control Systems. (...) Once the malicious programme has control of the device, it locks down access to the device and its functionality before demanding payment in the form of cryptocurrency (...)" Source

paper records and used workarounds (WhatsApp texting, use of personal gmail accounts) to take new orders (Greenberg, 2018).

Five months after the attack, the company recovered and rebuilt its network. It was reported that the company suffered “only” a 20% reduction in total shipping volume, due to the prompt efforts and manual workarounds. It is worth mentioning that this attack on Maerks was a disruption to the global supply chain, as other logistic companies and manufacturing industries were depending on timely delivery. (Saul, 2017). After this incident, Maersk took the appropriate actions heavily investing in cybersecurity and comitting not only to improve its cybersecurity, but also to make it a competitive advantage (Greenberg, 2018). This cyber-attack brought into light the vulnerability of IT infrastructure of the shipping industry which could be responsible for major disruptions. (Moore, 2017).

3. **The Coronavirus Disease (COVID-19) [2019-Onwards] - *(Case 3)***

As briefly mentioned earlier in Chapter 2, in 2019 the world had to face unprecedented situations where the effects of a widely infectious disease, the Coronavirus Disease (COVID-19)[23], created significant disruptions to the global supply chain and shipping operations.[24] To restrict the spread of the virus, ports closed, and shortages of labour and lockdown/quarantine mandates led to significant delays and surges in shipping costs. Quarantine measures also required that businesses closed, or if possible, applied remote-working policies, which led to consumers having to rely on e-commerce to satisfy their daily needs, increasing consumer demand and further straining logistics and shipping capacity[25]. Container shipping struggled to satisfy the surge in demand but shortages and imbalances worsened the delays and increased the costs[26].

4. **IMO 2020 Regulations [2020] - *(Case 4)***

The IMO 2020 regulations lowered the upper limit on the sulfur content of ships' fuel oil from 3.5% to 0.5% for ships sailing on the high seas to reduce their sulfur emissions[27]. To achieve the

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[23] Source
[24] Source
[25] Source
[26] Source
[27] Fan et al., 2020; Zis and Cullinane, 2020

new sulfur emissions target, shipowners were presented with the options of using low-sulfur fuel oils, retrofitting their ships with exhaust gas cleaning systems, also known as "scrubbers", or using non petroleum-based fuels or blends of fuels with sulfur content not exceeding the new limit (Zhu et al., 2020), (IMO, 2019). This regulation, which came into effect in 2020, led to significant changes in fuel prices, compliance costs, and operational practices within the shipping industry. These regulations triggered vast transformations in shipping and thus costs, and are regarded[28] as quite disruptive. With the upcoming effectiveness of the new regulations (around January 2020), in particular for the dry shipping sector, the costs relating to compliance with the new regulations were now, ultimately, borne by the shipowners instead of the customers of the transportation service (charterers), since the additional fuel cost stemming from the lower-sulfur and higher quality fuels was not incorporated in the freight rate. Additionally, shipowners were also required to invest in new technologies (i.e., installation of a scrubber) to meet these new standards, with both cases impacting their gross profit margins and operational efficiency (Sigalas, 2022).

5. Suez Canal Blockage [2021] - *(Case 5)*

In March 2021 the containership "Ever Given" disrupted global trade's routes between Asia and Europe. The ship had been blocking the Suez Canal, a vital waterway for global trade, for six days before being successfully salvaged, standing as a reminder of the importance of choke points remaining operational, as well as the significance of having a contingency plan to follow when such events occur. This disruption severely impacted global supply chains, caused significant backlogs and delays in delivery of goods across the world. It was reported that strong winds in combination with the canal's increased difficulty in navigation sent the ship off course. No injuries were reported, and thus the focus of the efforts went to minimizing the economic impacts. Shipping companies had to choose between waiting and risking a prolonged wait, or rerouting their vessels around the Cape of Good Hope, the former affecting the canal owner as well who missed revenue as fee-paying vessels chose to reroute. As reported by Hapag-Lloyd the industry experienced delays in the Far East, India-Europe/US, and Middle East-Mediterranean

[28] Miller, 2020; Mintzmyer, 2020

trade routes. Hapag-Lloyd reported its ships had been waiting outside the Suez Canal, and experienced port congestion when all the delayed ships finally reached their ports simultaneously.

For many parties, the event caused financial losses, increased waiting times and congestion at ports, delays, and claims that led to legal proceedings and one could argue that it has negatively affected the reputation of the company. The incident started discussions on diversifying shipping routes and actions to improve infrastructure to handle such disruptions.

Stakeholders' responses to this incident included (1) Rerouting: Shipping companies such as Hapag-Lloyd, reported to have diverted vessels around the Cape of Good Hope.
(2) Infrastructure Improvement: The Suez Canal Authority in response to this incident worked on deepening the southern section of the waterway and lengthening the parallel canal built in 2014.
(3) Embracing Proactiveness: Maersk's managing director, highlighted the importance of being proactive, and urged the global supply chain to embrace *'just in case approaches rather than just in time and as cheaply as possible.'* to be able to act efficiently in similar disruption scenarios, and to *"achieve better and quicker responses to disruptions"* .[29]

6. Russia-Ukraine War [2020 and Onwards] - *(Case 6)*

The Russian-Ukraine war put pressure on maritime trade as it triggered increases in costs, distances maritime cargo must travel, especially oil and grain. The economic sanctions against Russia due to its invasion in Ukraine, impacted the global supply chain. Due to the sanctions and logistical challenges, gas and oil importers resulted in engaging in business with alternative exporters, which led to increases in energy costs entraining marine bunker costs and increasing shipping costs.[30] Trade has been disrupted for commodities such as wheat, minerals and metals, oil and industrial inputs that Russia and Ukraine produce, resulting in the utilization of alternative sources and, consequently, raising the transportation costs[31]. Ukrainian ports have

[29] (1), (2), & (3): Source

[30] Source
[31] Source

been either closed, avoided or destroyed, also disrupting operations and trading. For final consumers of goods and services this is translated into higher prices.

7. Panama Canal Restriction [2023] - *(Case 7)*

The Panama Canal has had a significant effect in world trade as one of the world's key passageways since its opening in 1914. It is estimated[32] that on average 2.5% of global seaborne trade moves through it, with over fourteen thousand (14.000) vessels transiting through it in 2023 alone. On January 16, 2024 the Panama Canal Authority decided to reduce daily transits, due to drought causing low water levels in its reserves, resulting in a backlog of vessels waiting to transit it. Before the restrictions were applied the canal had an average of 36 vessels transiting through it per day. Since May 2024[33] and upon the completion of maintenance work, water level analysis, efforts to save water and increase storage, accompanied by a slight increase in rainfall levels in April, the number of daily transits is being gradually restored. The Authorities are now aiming to optimize transit operations while ensuring safe navigation through the waterway and estimate that normalized operations will have been achieved by 2025. (McKinsey & Company, 2024). Those disruptions caused consequent delays, congestion and possibly losses for shipping companies, contemplating the high-risk option of rerouting through the Suez Canal (due to the Red Sea hostilities in the area), or risking further diversions around South America. It also triggered an increase in rail and road transport services demand. (UNCTAD, 2024)

8. Red Sea Crisis [2023-2024] - *(Case 8)*

Escalating attacks towards ships at Red Sea off Yemen's coast, have been disrupting maritime transport and increasing costs for global trade since November 2023. Due to the increased risk in the area, vessels have been avoiding transiting the Suez Canal. In June 2024, sources[34] stated

[32] Source
[33] Source
[34] Source

that the volume of cargo (natural gas, oil, cars, raw materials and many manufactured products and industry components) dropped during May 2024 by 68.5% in comparison to May 2023 due to less ships transiting through the Suez Canal, with some shipping companies choosing to divert via Cape of Good Hope, circumnavigating the African continent. As for container shipping, it is worth noting that as reported by UNCTAD, in 2023, 22% of the global seaborne container had crossed Suez Canal towards the Indian Ocean, Atlantic Ocean of the Mediterranean Sea, while within the first six months of February 2024, 586 container vessels in total decide to reroute and lessening the container tonnage by 82% (UNCTAD, 2024). A drop in transit numbers is followed by a drop in revenue and foreign income for Egypt which might trigger negative effects on countries in the region (Ethiopia, Sudan). "Iranian-backed Houthi militants" targeting various types of ships (chemical oil tankers, bulk carriers, container ships etc.) with an array of sophisticated weapons - such as ballistic missiles and "kamikaze" drones[35] is a new type of threat for the ships navigating the area, which was previously known for its high piracy risk. Thus, security measures employed on the ships passing through this area now have to be updated and increased, which requires maritime security organizations', maritime security companies' and shipping community's coordination and vigilance.

9. USA: Port Workers' Strikes and Protests Against Automation [2024 - Onwards] - *(Case 9)*

On October 1st 2024, dockworkers strikes across 36 of the US East and Gulf coasts ports caused great concern and uncertainty for many Logistics and operations stakeholders, with no real indications on their duration or extent of damages the strikes could cause. The timing of the strike threatened the festive supply chains with paralysis, delivery delays and increased costs and shortages, also affecting consumers. Moreover, it was estimated that a one-week strike could have a significant impact on the U.S. economy, costing $3.78 billion as reported by the Conference Board.[36]

[35] Source
[36] Source

This strike, being described as "one of the largest labor actions in decades", involved approximately 45,000 dockworkers. Just two days later, on October 3rd 2024, after negotiations, a tentative agreement was reached between the port workers representative, the International Longshoremen's Association (ILA) and the U.S. Maritime Alliance, granting the former a historic wage raise of 61.5% over six (6) years, while at the same time allowing additional time for further negotiations regarding automation and health benefits until January 2025.[37]

Experts argue[38] that disruptions from strikes such as this, are not just a short-term challenge but are indicative of the supply chain instability, representing a "new normal" requiring companies' preparedness for future disruptions.

[37] Source
[38] Source

3.2 Disruption Management

There are actions that can be taken to manage disruptions and mitigate risks. From the cases mentioned in the previous subchapter, presented below are the strategies and actions that managed these disruptions. The relevant table (Fig. 3) shows the Strategy and the corresponding Case.

- **Rerouting** was seen in **Cases 7 and 8.** The vessels used this strategy and avoided the risk, as seen in the Red Sea case, by not transiting through an area with ongoing hostile acts. Choosing to reroute the vessel was seen as a safer option by the stakeholders, concenring for the crew, the ship and the environment in comparison to transiting an area of increased risks of attack. **Rerouting** in **Case 8,** was practised when instead of transiting through the Panama Canal, to reduce waiting times, vessels with cargo from Asia were **rerouted** through the Suez Canal (prior to the Red Sea crisis), as per UNCTAD's report**.** (UNCTAD, 2024). In **Case 5,** rerouting vessels was also a strategy that was chosen by shipowners, when faced with the Suez Canal disruption.
- **Proactiveness** utilized as a strategy to anticipate disruptions, was seen in **Case 8.** The Panama Canal authority encouraged shipping lines to **act proactively** and use reservations and priority booking offered by the Panama Canal to reduce waiting times (McKinsey & Company, 2024). **Adopting proactive strategies** was also advised by Maersk's managing director as seen in **Case 8**.
- **Leveraging infrastructure** was another strategy used in **Case 8**. The government of Panama is planning[39] to leverage existing infrastructure (roads, railways, port facilities, airports, and duty-free zones), offering a sustainable alternative of a dry route to the water bridge.
- **Redirecting containers with overland transportation** was another strategy implemented, seen in **Case 8**. Liner giant Maersk at the beginning of 2024 adopted a temporary solution[40] to address the Panama disruption, dividing its Pacific route into two and choosing the **overland transportation of containers** between the vessels on the

[39] The Multimodal Dry Canal project

[40] The company announced it would restore the single ship routing as of May 2024, eliminating the need to move containers overland.

Atlantic and the Pacific. Other ports have also adopted this strategy, with the example of the Port of Salalah[41] offering an **overland route** to avoid risks relating to the Red Sea situation, seen in **Case 8**. To mitigate the effects of the Russia-Ukraine war, carriers resorted to **land and maritime transport** infrastructure and services. Similarly, in **Case 5,** carriers leveraged onland transportation to avoid the Suez Canal disruption.

- **Stronger focus on the financial health** and stability of shipping companies, shippers **establishing backup plans**, and seeking **alternative carriers** were strategies implemented in **Case 1** to ensure continuity in operations after Hanjin's bankruptcy.
- **Implementing financial safeguards** across the industry was another strategy seen in **Case 1**, to prevent similar collapses in the future.
- **Utilizing alternative sources and commodities** was presented in **Cases 5 and 6,** to avoid disruptions due to the Russia - Ukraine war and the Suez Canal blockage.
- The strategy of utilizing **alternative maritime transport infrastructure and services** was adopted by carriers, seen in **Case 6**, as a means to mitigate the effects of the Russia-Ukraine war.
- **Waiting** to enter the Suez Canal instead of rerouting was a strategy some shipping companies opted for in **Case 5.**
- **Investing in cybersecurity technologies and measures** was seen in **Case 2.**
- Using **low-sulfur fuel oils** and **retrofitting scrubbers** was seen in **Case 4** as a more cost-friendly option shipowners chose in order to comply with the **IMO 2020** regulations, which nevertheless still narrowed shipowners' margins.
- **Updating and Increasing the security measures** was seen in **Case 8,** to enhance safety for ships that navigate the Red Sea area**.**
- **Strengthening the communication**, **coordination and cooperation** between security organizations, maritime security companies and the shipping community was presented in **Case 8.**
- **Communicating and negotiating** were strategies used in **Case 9,** in order to end the strike.

[41] Source

- **Increasing Speed** was seen in **Case 5**, where shipping companies adjusted the speed of the vessel, a strategy utilized to compensate for the longer transit time relating to the Suez disruptions.
- Shipping companies implemented **digital technologies and automation** to their operations, and **diversified their supply chains** to combat the effects of the COVID-19, as seen in **Case 3**, as means to enhance their resilience and efficiency by and to rely on local production instead of global logistics.[42]

#	Disruption Management Strategy Used	Seen in Case(s)
1	Rerouting	5,7,8
2	Redirecting containers with overland transportation	5,8
3	Utilizing alternative sources and commodities	5,6
4	Investing in digital technologies, automation, cybersecurity technologies and measures	2, 3
5	Leveraging Infrastructure	8
6	Embracing Proactiveness	8
7	Stronger focus on the financial health	1
8	Establishing backup plans	1
9	Implementing financial safeguards	1
10	Alternative maritime transport infrastructure and services	6
11	Waiting	5
12	Using low-sulfur fuel oils	4
13	Retrofitting scrubbers	4
14	Updating and Increasing the security measures	8
15	Strengthening the communication, coordination and cooperation	8
16	Communicating and negotiating	9
17	Increasing Speed	5
18	Diversifying supply chains	3

Fig. 3 Disruption Management Strategies and Their Corresponding Cases.

[42] Source

Disruption Management Outcomes

Even successful disruption management can come with a cost for the shipping company, transportation network, supply chain or the final consumer.,

Although **Hanjin's Collapse *(Case 1)*,** was not avoided, it reminded the industry of the need for alternatives/backup plans and safeguards, and the impact a company's financial health can have on the international shipping industry.

The **Cyber-Attack on Maerk *(Case 2)*** highlighted the importance of investing in cybersecurity and implementing cybersecurity protocols and procedures and contingency planning. The industry's response to increase its protection against cyber threats was to invest in cybersecurity measures and protocols and the development of industry-wide standards and best practices to protect against cyber threats.

The **Coronavirus Disease *(Case 3)*** profoundly disrupted shipping and the global supply chain. The outcomes from such an unprecedented situation were severe disruptions such as lockdowns, port closures, workforce shortages and problems associated with inadequate crewing, port congestions, delays, bottlenecks. This disruption increased costs as the fragile supply chain struggled to respond to the challenging times. On the other hand, this situation increased resilience, showcased the importance of the diversification of suppliers and sourcing from suppliers at a smaller distance. Furthermore, even with the economic uncertainties, companies chose to invest and implement technology and digital tools used for forecasting and tracking. Organisations focused on making the supply chain and shipping operations sustainable, and took a collaborative approach to mitigate risks.[43]

As the industry was proceeding to the necessary actions to comply with **IMO's 2020 requirements *(Case 4)*,** and while generally regarded as having a positive impact on the natural environment in the long term (Kontovas, 2020), it was reported to have had a negative impact on shipping companies' bottom line, to which, a recommended solution to the shipowners to recover from the narrower profit margins it came with, was *slow steaming*. (Sigalas, 2022).

[43] Source 1, Source 2, Source 3

Suez Canal blockage ***(Case 5)*** disruption management resorted in the rerouting of vessels, rerouting cargo, using onland transportation leveraging existing infrastructure. It had benefits and challenges. Strategies and measures that were used, avoided or mitigated risks and more disruptions, reduced congestion at ports but also increased transit time, and costs for the shipping companies. It also brought logistical challenges, increased risks relating to poor performance / management (such as lack of coordination/increased costs/increased time needed for transportation of goods. At the same time, it increased exposure to perils of the sea due to longer transit time and carbon emissions as speed[44] was increased to compensate for longer transit time. Freight rates also increased. Amongst others, the consumer was negatively affected (i.e. delays in delivery, increased costs led to increased prices), and the affordability of goods for consumers was also possibly affected due to increased transportation costs. There were environmental consequences due to increased transit durations and added load to the overland transportation network. It was highlighted that new or upgraded infrastructure may provide a sustainable alternative supporting long-term trade growth. Shipping companies and stakeholders need to adapt and invest in alternative routes as well as diversify their routes as means to combat the effects of such disruptions.

One could argue that the outcomes from the implementation of disruption management strategies concerning the **Russia-Ukraine War** ***(Case 6)*** global vessel demand increased due to sourcing commodities from further away and carbon emissions increased from longer transit times. However, the implementation of alternative routes to avoid the increased risk in the area, also increased the costs for marine fuels and shipping costs. The consumer was affected with delays in delivery, decreases in supply and increased costs led to increased prices etc.

Panama Canal Restrictions ***(Case 7)*** prompted disruption management strategies such as rerouting vessels, leveraging onland transportation, and utilizing existing infrastructure. These measures helped mitigate risks, avoid further disruptions, and reduce congestion. However, they also led to increased transit times, higher costs for shipping companies, and logistical challenges, including coordination issues and extended transportation times. Consumers faced delays in delivery and higher prices, while environmental impacts increased due to longer transit

[44] Source

durations. The disruption highlighted the need for infrastructure upgrades and diversification of routes to support long-term trade resilience.

The Red Sea Crisis *(Case 8)* disruption management involved rerouting vessels to avoid risks and further disruptions, but it introduced challenges like increased transit times, shipping costs, and port congestion. Consumers were negatively impacted by delays, shortages, and higher prices, affecting the affordability of goods. Environmental consequences arose due to longer transit durations, and higher insurance premiums reflected the heightened risk in the region. Reduced vessel traffic through the Suez Canal and Red Sea had economic implications for local countries, emphasizing the need for route diversification and stakeholder investment in alternative solutions

The announced USA Port Workers' Strikes and Protests Against Automation *(Case 9)* caused experts to explore the possible preventative measures such as extended operational hours and special protocols for refrigerated shipments, along with surcharges on shipments to East Coast ports. Anticipated delays led to the thought of diversions, for transshipment. However, this was finally deemed infeasible due to limitations in capacity limitations. These disruptions highlighted risks of over-reliance on single vendors and emphasized the importance of diversified and adaptable supply chains as a business necessity.[45]

[45] Source

3.3 Cases of Technology Implementation for Disruption Management

Technology has come to improve efficiency, streamline activities, and assist in achieving transparency and sustainability in shipping. Implementing technologies helps monitor, manage, maintain and improve quality of services and transferred goods, provide useful information, tracking and control, cost optimization, fuel consumption and emission control. The two cases mentioned below are small examples of how technology implementation can benefit shipping activities.

1. **Maersk's Implementation of Blockchain Technology**

In 2018, one of the world's largest[46] container shipping company, Maersk, announced a collaboration with International Business Machines Corporation (IBM), to build a new global trade platform with the use of blockchain technology. The scope was reducing the cost of global shipping, improving supply chain visibility and eliminating inefficiencies from paper-based processes (Scott, 2018). The result was the TradeLense platform that was destined to be used by various stakeholders of the supply chain such as other carriers, shipping companies, port operators, customs authorities and other trade partners, to facilitate and accelerate the digitization of the supply chain whilst providing transparency, visibility, streamlining the documentation and tracking relating to containers. With the introduction of this platform, Maersk aspired to create a secure and immutable transaction record, with real-time access to shipping data which could reduce delays relating to container clearance, and consequently also reduce costs. With the implementation of this blockchain based platform, administrative paperwork and delays would be also reduced, increasing efficiency and transparency, achieving visibility into the supply chain. Finally, with the tamper-proof records of blockchain technology, data security would be improved, reducing the risk of fraud.

In 2022 the discontinuation of IBM and Maersk's initiative (TradeLense) was announced, ending operations in the first quarter of 2023[47]. Industry experts argue that this initiative's success required competitors collaborating and Maersk convincing the shippers and freight-forwarders of

[46] Source
[47] Source

the added value it would bring, for them to invest. It is also argued that these were not achieved due to lack of incentives, and due to the benefit of the data provided beyond the shipping lines being small, as data from terminals, port community systems or freight forwarders was "very low and did not generate value". The high operational costs of the platform, and thus there was a high price to be paid by the customers rendered the initiative unviable.

Even Though this initiative did not succeed, Maersk committing to and investing in blockchain was regarded as an indication that technology can be used to solve problems in shipping. Even after the TradeLense's shut down, Maersk declared to continue using blockchain technology for its internal operations.[48]

2. CMA CGM's Smart Container IoT Solution

In 2019, Compagnie Maritime d'Affrètement Compagnie Générale Maritime (CMA CGM), the world's third largest[49] container shipping company, understanding the importance of monitoring the conditions and status of cargoes while in transportation, introduced smart containers for refrigerated and dry goods, providing their clients with additional tracking and traceability options. The technology implemented for the smart containers harnesses the power of the Internet of Things (IoT) technology. The company's smart containers are fitted with IoT sensors that continuously gather data, which is transmitted to a dedicated online interface, updated in real time, for monitoring and analysis. This data can provide real-time monitoring of the container's location, and information on its conditions such as temperature, and gas variations.

Notifications can be set up when detecting anomalies, enabling the implementation of corrective measures, and alerts about the intensity of possible shocks, container doors' opening and closing, and outside temperature variations.

As a result, the management of perishable goods can be improved, reducing the amount of spoiled goods and ensuring quality, as the goods arrive at their final location in the required condition.

[48] Source

[49] Source

In this example it is demonstrated that the implementation of IoT technology in shipping, can provide visibility, with real-time tracking of container conditions. Continuous monitoring allows the customer to take a proactive approach, increasing the chances of successfully intervening to any possible issues that could be disruptive. At the same time the IoT technology is assisting in quality control for sensitive and perishable goods, potentially reducing economic concerns. Finally, the IoT technology is used to enhance transparency and provide accurate tracking information to the customer, who ultimately enjoys better service reliability, minimizing risks.[50]
This technology had been also implemented by major shipping container companies such as MSC and Happag Lloyd, and when customers' demand for visibility increased due to the COVID-19 pandemic restrictions effects on the supply chain, this technology solution satisfied this request. The estimation of the Chief Executive Officer (CEO) of the Digital Container Shipping Association is that it is "just a matter of time" before the IoT containers are universally adopted due to the added benefits they enable[51].

3. Mediterranean Shipping Company's (MSC) Use of ML and AI

The Mediterranean Shipping Company (MSC), the world's largest container shipping company[52] leveraged the power of Machine Learning (ML) and Artificial Intelligence (AI) to optimize fuel consumption and to maintain operational efficiency of its fleet. MSC's latest press release talks about its 2023's sustainability report, where one of the company's milestones was reducing its carbon intensity rating to 13.46 (Energy Efficiency Operational Indicator (EEOI)), "all time low" for the company. Amongst other factors contributing to this milestone, the company bestows this success to the implementation of a data-driven vessel management system using machine learning and AI to optimize energy use, which optimized its vessels' performance. A welcome "side effect" of optimizing energy use is often fuel savings, reduction in greenhouse gas emission, and compliance with environmental regulations.

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[50] Source
[51] Source
[52] Source

Chapter 4: Risk-Assessment on Real-Life Scenario for Disruption Management

For this dissertation, the author contacted an esteemed and established *Greek tanker shipping company*[53] whose fleet comprises 7 tanker ships operated by the Company, in an attempt to study its Risk Assessment practices implemented for HSQE aspects related to the management of ships. The author is thankful to be provided with material granting valuable insight into the means and ways the Company utilizes, to strategically and technologically address matters relating to disruptions and risks. Such material is vital for the real life scenario approach the author desires to provide within this dissertation.

It is important to mention that the Company's HSQE Management System (HSQEMS) has been certified as compliant with the international standards of the ISM Code, ISO 9001, ISO 14001, ISO 45001, ISO 27001. Additionally, the Company operates vessels under a Quality Management System certified to ISO-9000 and an Environmental Management System certified to ISO-14000. The Company's HSQE Management System (HSQEMS) has been designed to be in line with the requirements of said international management systems standards.

Moreover, the Company has implemented an integrated approach to HSQE, through an HSQEMS which is operations-specific, and aims in reducing risks relating to health, safety and environment to as low as reasonably practicable. It also addresses risks arising from the cargo, transit and maintenance operations of the Company's vessels, as well as other issues (port specific HSQE issues, e.g. presence of known traffic control problems, restrictions, mooring and loading arrangements) on a case-by-case basis. It is also important to mention that the appropriate familiarization and training is necessary for all company employees whose actions might affect HSQE aspects.

The Company has established a formal management system (HSQEMS) for the management of ships addressing operational aspects relating to the (a) Safety of ship, (b) human life, (c) cargo and other property and (d) protection of the environment, (e) Quality of ship management service

[53] Onwards referred as "The Company".

provided to its clients, (f) Environmental effects arising from its activities or products used (g) Occupational health effects for matters related to ship crew to enhance the protection of the company's people, assets, reputation and protection of the environment.

Presentation of the Company's HSQE Management System's Structure

The company's HSQEMS structure outlines the methods of identification of risks and hazards, necessary resources, legal requirements, necessary controls for safe operations, responsibilities and authorities, required training, actions amidst an accident or emergency, requirements compliance records, methods of suitable communication and document control, HSQEMS improvement procedures, HSQE related performance metrics, review and auditing and procedures.

In detail the Company's HSQE includes:

1. Methods for identification of all risks and hazards and the analysis of their significance including methods to identify equipment and technical systems the sudden failure of which may result in hazardous situations
2. Methods for identification of all legal and other requirements
3. Methods for identification and provision of all required resources (people, qualifications, equipment, contractors, materials, financial resources, services etc.)
4. Determination of all required responsibilities and authorities as defined by the appropriate company organization charts and company procedures.
5. Determination and provision of the necessary training
6. Determination of the controls needed to carry out all key operations in a safe and effective way. Controls include:
    a. suitable and qualified personnel
    b. appropriate and properly maintained equipment
    c. appropriate working environment
    d. availability of the necessary documents, including applicable legislation and plans and instructions for key shipboard operations concerning HSQE
    e. provision of the necessary instructions

   f. Scheduled inspections with pre-defined acceptance criteria.
7. Actions to be taken in case of an accident or an emergency condition to control and mitigate the consequences and relevant emergency preparedness drills
8. Controls to ensure that all activities, engaged in or contracted to other companies, are managed in a way that satisfied the company's requirements for HSQE
9. Determination of the records that need to be maintained to demonstrate compliance with the requirements
10. Suitable communication and document control methods to ensure that all information related to HSQE matters reaches the person(s) responsible for using it and taking action
11. Procedures for improving the HSQEMS through investigation of failures, accidents and hazardous occurrences, finding their root causes and taking the appropriate corrective or preventive action.
12. Performance criteria and indicators to provide a measure on the Company's success in achieving its HSQE objectives
13. Procedures for conducting internal and external audits and reviews by the Company's management in order to assure that the HSQEMS is being adhered to and that it is suitable to satisfy the requirements. Auditing is directed toward measuring compliance with an accepted and known standard, whereas management review is concerned with not only compliance but also overall HSQEMS effectiveness and continued suitability for purpose.

It is determined that the Company's HSQEMS aims to establish proactive and reactive methods, strategies and procedures for the management of disruptions and mitigation of risks.

Risk Assessment: Roles and Responsibilities

Within the company's HSQEMS, the responsibilities are assigned. All employees have the responsibility of identifying risk and can request a Risk Assessment through the DPA or their Department Head or the Master. The DPA or the Department Head or the Master then reviews the request to decide whether a Risk Assessment should be conducted.

Once the need for Risk Assessment is determined, the DPA or Department Head or Master or Chief Engineer (upon Master's order) initiates a Risk Assessment using a company form which will be described further down this chapter. The appointed Risk Assessment team then performs the Risk Assessment and provides the completed form which is then reviewed by the DPA or Department Head(s). The DPA, Department Head, Master or the CEO (if required) approves the control measures and either the DPA, Department Head or Master implements them. Qualified appointed persons then have to verify the control measures and the DPA or Master is responsible for record keeping.

Risk Assessment: Demonstration of Hazards

The Company's Risk Assessment process includes the identification, evaluation and understanding of hazards or the potential of hazards and their controls. Furthermore, the Company has systems to identify physical hazards in the field of operations, as well as potential hazards due to hazardous situations or hazardous events, hazards relating to tasks or occupations, or inherent hazards related to the work environment, location, or adjacent/nearby activities, operations, (simultaneous operations), etc. For each, the company provides evidence of a systematic analysis and its results. For hazard identification, the company utilizes Risk Assessment where through identification, evaluation and classification, the best method of risk management is decided with which the risk can be eliminated, controlled, tolerated, or transferred. Additionally, this process must be carried out by qualified persons.

The Company maintains a Hazards & Effects register, which demonstrates all potential major hazards have been identified, the risk from these hazards evaluated and understood, and the controls to manage the cause and consequences are in place.

The Company also refers to historical evidence of past accidents or incidents within the Company or the industry and to regulatory requirements, which provide valuable information for hazard identification and risk assessment. Company has identified types of hazards, including (i) Equipment operation, (ii) Onboard equipment use, (iii) Workplace design, (iv) Pollution and other environmental hazards, (v) Hazardous substances, (vi) Adjoining activities, and (vii) Materials handling.

Risk Assessment: Defining & Identifying Hazards

For hazard **identification** the Company's process dictates the provision of documented evidence that all the potential hazards that could affect the vessel have been identified and reviewed. For each potential hazard source, their applicability to the vessel, threats and consequences must be evaluated.

The Company has defined risk tolerances presented within a **qualitative risk matrix** format, demonstrating the relationship between frequency and consequences of an event (i.e. *risk*). This analysis aims to **assess** the impact on assets, personnel, environment, and reputation of the Company in case of a hazardous event and is based on **historical data** and on **judgment**.

The Company's Hazards & Effects register holds the **results** of the analysis made of each hazard and effect associated with the operations, specifically, the Company uses a *"bow-tie"* format.

The Company has also provided guidelines *(Fig. 4)* on establishing the appropriate controls/barriers to manage risks efficiently while simultaneously controlling the costs for various risk levels, which, ultimately, defines the acceptance criteria. Furthermore, indicators of the effectiveness of barriers provided by the company which are categorized as: **Very Good (++)** where there is a technical barrier in place which does not depend on the human factor (i.e. an automation, a safety valve etc), **Good (+)** where there is a barrier in place which depends on the human factor to operate (i.e. procedure implementation) and **Questionable (?)** where there is a barrier which is out of the company's control (i.e. assistance from shore).

CONTROLS	INTOLERABLE RISK HAZARDS	HAZARDS REQUIRING RISK REDUCTION MEASURES	HAZARDS REQUIRING MANAGEMENT FOR CONTINUOUS IMPROVEMENT
Threat Barriers	Minimum of 3 independent, effective barriers to be in place for each identified event	Minimum of 2 independent, effective barriers to be in place for each identified event	No acceptance criterion because outside scope of hazard analysis
Recovery Preparedness Barriers	Minimum of 3 independent, effective recovery measures requiried for each identified consequence (including one to automatically detect occurrence of top event, and one other to prevent further escalation	Minimum of 2 independent, effective recovery measures requiried for each identified consequence (including one to detect occurrence of top event, and one other to prevent further escalation	No acceptance criterion because outside scope of hazard analysis
Escalation Factor Controls	Minimum of 1 independent effective control for each identified escalation factor	Minimum of 1 independent effective control for each identified escalation factor	No acceptance criterion because outside scope of hazard analysis

Fig. 4: Control barriers needed to treat different hazards categories.

Risk Assessment Library

The Company maintains a common Risk Assessment (RA) library, along with an Index with all the received and reviewed Risk Assessments carried out either by the Fleet or the Office. Prior to an operation or job, the RA library is reviewed to determine whether a relevant RA already exists or if a new Risk Assessment should be carried out and then sent to the Company for notification purposes if low risk or approval if medium/high risk.

Risk Assessment Matrix (RAM)

As already mentioned at the beginning of this chapter, the company has established a qualitative risk analysis matrix to assess risk which is based on the Company's historical data on incidents/accidents and judgment of the **adequately trained** person who will be conducting the assessment.

The Company's Risk Assessment Matrix (RAM) *(see ANNEX A)* provides guidance for the assessor and presents each risk rating or risk category level. Color coding is used to make each rating easily distinguishable to the reader. Numbers 1 to 5 are used to signify the **Severity.** of the event. As the numbers increase, so does the severity of the event: **1-Slight, 2-Minor, 3-Significant, 4-Severe, 5-Major**. Letters A to E are used to indicate the **Frequency** of the occurrence of an event: **A-Rare, B-Unlikely, C-Remote, D-Occasional, E-Frequent.** The RA is used to assess the consequences of an event on **People, Assets, Environment** within the area of operation and on the **Reputation**, and indicates the **risk category**, using color code; **green** to indicate **"Manage for Continuous Improvement"**, **yellow** to indicate the need to **"Incorporate Risk Reduction Measures"**, and **red** to signify an event that would be "**Intolerable**" for the company. When conducting the risk assessment, the assessor is required to use the "1-5" severity ratings , the "A-D" frequency ratings, and color-codes.

4.1.2 Conducting the Risk Assessment

This Risk Assessment evaluates the risk of one of the Company's crude oil tanker ships side-colliding with an approaching service vessel to conduct an offshore ship-to-ship (STS) bunkering operation. Moreover, after an **Initial Risk** (IR) evaluation, the company mitigates the risk, placing safeguards which lower the risk category of the threat.

To conduct the Risk Assessment, the Company has established a procedure, in accordance with the manual presented in the previous subchapter. In advance of the commencement of the activity (operation), the person responsible on behalf of the company conducts an IR assessment and fills out a form *(Fig. 5.1* which is delivered to the vessel. The form includes the description of the activity for which the risk will be assessed**,** the description of the **hazardous event**, the **consequences**, the **causes** leading to the threat, the company's **existing control measures** and the **IR evaluation** on its personnel, assets, the environment and the company's reputation, along with the **IR Evaluation Result** presented in a matrix format. The person responsible on behalf of the vessel then delivers to the company the **Risk Treatment** matrix with the **Safeguards** which are actions to be taken following the assessment, the **Responsible Person** for the safeguards, the **action timeline**, and the **Residual Risk (RR) Evaluation** on Personnel, Assets, Environment and Reputation *(Fig. 5.2.1)*.

4.1.3 Description of the Activity

In the Risk-Assessment form, the description of the activity being assessed is provided. Amongst others, information on the **personnel** required to be involved in this work process (“all crew”), the **category** of the situation (“Routine Situation”), and whether a request of **management of change** has been made and by whom, along with **the reason** (here not requested). The **Task ID** number makes reference to a code indicating the associated section of the Hazard Identification sheet of the Company. Finally, it is indicated that all **Personal Protective Equipment (PPE)** needed, should be the items indicated in the Main Shipboard Manual of the HSQEMS of the Company. Other fields are left blank as they do not affect this Risk Assessment example (*Fig. 5.1*).

Generated by: Vessel …(name)… / Office …(dept)…	**Date issued :** … / … / …	**Management of Change issued requested by : NONE**			
Operation/Work activity being assessed : SIDE COLLISION WITH APPROACHING SERVICE VESSEL	**Routine / Non-Routine / Emergency Situation : ROUTINE**				
Management of Change Operation (if any) : N/A	**Reason for the Management of Change (if any) : N/A**				
Personnel involved in work process (at risk) : ALL CREW	**Task ID Number** (associated sections of HAZID log sheet)**: H-4 (4.2)**				
Deadline for completion : … / … / …	**Status :** Open / Close / Pending				
Permit to Work Systems Required (tick where appropriate)**:**	Enclosed Space Entry: …	Hot Work: …	Cold Work: …	Electrical isolation Certificate: …	
Aloft/Overside: …	Pressure Vessel/Pipeline: …	Energy Containment Systems: …	Transfer by Basket: …	Small Craft Alongside: …	Unscheduled Work: …
PPE (List the required PPE as per Matrix for PPE use, Main Shipboard Manual, Chapter 8) **: ALL PPE AS PER COMPANY’S MATRIX**					

Fig. 5.1: Description of the activity being assessed.

4.1.4 Initial Risk Assessment

Following the description of the activity, next is conducting the initial risk assessment. The hazardous event of the vessel being involved in an incident where there is side collision with the approaching service vessel, has been identified to have **consequences** on 1. Structural Damage, 2. Pollution, Fire/Explosion and may be **caused** by one or more of the following: Navigational Error, Poor Visibility, Main Engine Failure, Electrical Failure, Communication Error, Persons involved in the operation being unfit to work.

To complete the initial risk assessment form the Company requires the assessor to refer to the company's Hazard Identification log sheet (HAZID), which was not disclosed in its entirety for company data protection reasons. Nevertheless, the necessary data for this Scenario were provided and can be found further down this chapter.

During the initial risk assessment, the assessor, on behalf of the Company's office, names the existing control measures applicable to each consequence.

For this Scenario, to control *Structural Damage*, the assessor enumerates three existing control measures the Company has in place; the initiation of Company emergency response procedures, monitoring the work vs rest hours of the crew, and the crew's competency and familiarization with the task.

For the existing control measures for *Pollution* the Company indicates the initiation of Company emergency response procedures, monitoring the work vs rest hours of the crew, the crew's competency and familiarization with the task, oil leakage training and drills, as well as the anti-pollution equipment and materials that are on the vessel.

For the *Fire/Pollution* existing company controls, the assessor enumerates the initiation of Company emergency response procedures, monitoring the work vs rest hours of the crew, the crew's competency and familiarization, firefighting training and drills, and fire-fighting equipment on the vessel.

After listing the existing control measures the company has implemented, the assessor makes the initial risk evaluation by completing the relevant slots of the matrix; P, A, E, R, which stand for People, Assets, Environment and Reputation respectively.

4.1.5 Interpreting the Risk Assessment Matrix

Initial Risk Evaluation

According to the company's historical data and judgment criteria of the evaluator, the activity's initial risk of causing the hazardous event of a side collision with the approaching service vessel were assessed as follows:

Structural Damage

One of the consequences is **structural damage** on the ship and is evaluated to have an initial risk for **People** of **D2** level. According to the Company's Risk Assessment Matrix *(see ANNEX A)*), D2 indicates structural damages happen occasionally, and more specifically once a year within the entirety of the Company's fleet (D), causing minor accidents (2), such as minor injury, lost time, reversible health effects. The same risk categorization (**D2**) has been assigned to the Company's **Assets.** Structural damages can happen occasionally (D), more specifically once a year within the entirety of the Company's fleet with minor consequences causing possible short disruption of operations, specifically less than a week, with a repair cost of $100,000 or less.

The initial risk of structural damage threatening the **Environment** within which the activity (operation) takes place, is **D1**, indicating that structural damage, occasionally (D) -more specifically once a year within the entirety of the Company's fleet- has consequences of slight severity on the environment, which could be a minor release contained onboard with no environmental damage (1).

For **Reputation**, the initial risk is indicated as **E2**, where structural damage on the ship might happen Frequently (E), more specifically once per year per vessel,with consequences of minor (2) Severity that only affect some internal (reputational) aspects of the Company.

Pollution

The initial risk of the activity causing **Pollution** is assessed as **C3** for **People**, **Assets**, **Environment** and **Reputation**. This indicates that once in the Company's fleet, or once per year in the worldwide fleet (C) this activity might cause significant (3) consequences for the People such as permanent or partial disability or significant irreversible health effects. On the Assets the consequence might be that operations being temporarily halted and high repair costs are required. This might have significant environmental impact on the Environment, and requires significant measures to restore the contaminated environment. Concerning the company's Reputation, pollution incidents have a significant impact on the reputation of the company with country-wide effect on reputation and/or media coverage.

Fire/Explosion

The initial risk for the activity causing **Fire / Explosion** is evaluated as **C5**, and indicates an **intolerable risk** for the **People**. The activity is evaluated as a **major accident hazard**, with remote likelihood, having occurred once in the Company's fleet, or once per year in the worldwide fleet (C) with major (5) consequences for people such as multiple fatalities. For **Assets**, **Environment** and **Reputation** assessed at **C4** level, Fires/Explosions have occasionally (once a year within the fleet) caused severe consequences with partial loss of a ship, loss of trading for approximately 6 months, repairs of up to 10 mil., had severe environmental impact and extensive measures were required to restore the contaminated environment, as well as severe emissions. For the company's Reputation, the activity is evaluated as a **major accident hazard**, with severe impact due to country-wide effect on reputation and national and international media coverage.

Injuries

For **People,** the initial risk evaluation for Injuries, indicates a risk of **D2** level. D2 indicates this activity occasionally, and more specifically once a year within the entirety of the Company's fleet (D), may cause minor accidents (2), such as minor injury, lost time, reversible health effects.

For the Company's **Assets,** the initial evaluation of the risk is at **D2**. An injury, occasionally (D) -more specifically once a year within the entirety of the Company's fleet- has minor (2) consequences causing possible short disruption of operations, specifically less than a week, with a cost of repair less than $100,000.

Regarding the **Environment**, the initial risk evaluation is at **D1**,which indicates an injury occasionally, and more specifically once a year within the entirety of the Company's fleet (D), may cause minor releases contained onboard with no environmental damage (1).

About the company's **Reputation,** the initial assessment has a risk of **E2**, which indicates that injuries occur frequently, once a year per Company ship, which raises internal concerns within the Company.

Man Overboard (MOB)

The initial risk evaluation concerning **People** is **C2**. This indicates that once in the Company's fleet, or once per year in the worldwide fleet, a MOB incident may cause minor accidents (2), such as minor injury, lost time, reversible health effects.

For **Assets,** the rating is **C2,** once in the Company's fleet, or once per year in the worldwide fleet (C), a MOB incident has minor (2) consequences causing possible short disruption of operations, specifically less than a week, with a cost of repair less than $100,000.

For the **Environment** the rating is **C1**, indicating that once in the Company's fleet, or once per year in the worldwide fleet (C) a MOB incident might have consequences of slight severity which could be a minor release contained onboard with no environmental damage (1).

Finally, for **Reputation** the initial risk is assessed at **D2** which indicates that this activity causing a MOB incident, occasionally, and more specifically once a year within the entirety of the Company's fleet (D), may raise internal concerns within the Company. The Initial Risk Evaluation is seen below *(Fig. 5.2.1*) as well as its results *(Fig. 5.2.2)*.

During the initial risk evaluation, the evaluator has to examine whether there is an alternative way to perform this activity, to avoid risks or choose an option with less risk *(Fig. 5.2.3)*.

RISK ASSESSMENT								
Hazardous event [2]	**No.**	**Consequences** [3]	**Causes** [4] (leading to the threat)	**Existing Control Measures**	**Initial Risk Evaluation**			
					P	**A**	**E**	**R**
Side collision with approaching Service vessel	**1.**	**Structural damage**	1. Navigational error 2. Poor visibility / severe weather conditions 3. M/E failure 4. Steering gear failure 5. Electrical failure 6. Communication error 7. Unfit to work	1.1 Initiation of Company emergency response procedures (Emergency Response Plan, SOPEP, VRP) 1.2 Work – Rest hours monitoring 1.3 Crew competency and familiarization	**D2**	**D2**	**D1**	**E2**
	2.	**Pollution**		2.1 Initiation of Company emergency response procedures (Emergency Response Plan, SOPEP, VRP) 2.2 Work – Rest hours monitoring 2.3 Crew competency and familiarization 2.4 Oil Leakage training and drills 2.5 Anti-pollution equipment and materials	**C3**	**C3**	**C3**	**C3**
	3.	**Fire / explosion**		3.1 Initiation of Company emergency response procedures (Emergency Response Plan, SOPEP, VRP) 3.2 Work – Rest hours monitoring 3.3 Crew competency and familiarization 3.4 FF training and drills 3.5 Fire fighting equipment 3.6 PPE	**C5**	**C4**	**C4**	**C4**
	4.	**Injuries**		4.1 First Aid & vessel's hospital 4.2 Work – Rest hours monitoring 4.3 Crew competency and familiarization 4.4 PPE 4.5 Shore assistance	**D2**	**D2**	**D1**	**E2**
	5.	**M.O.B.**		5.1 Notification of responsible parties 5.2 Life saving appliances 5.3 Shore assistance 5.4 Crew competency and training	**C2**	**C2**	**C1**	**D2**

Note P: People, A: Asset, E: Environment, R: Reputation

Fig. 5.2.1 Initial Risk Evaluation table

INITIAL RISK EVALUATION RESULT	**Major Accident Hazard**	**Risk Categories** [7] (Tick as appropriate)		
		Manage for continuous improvement	**Incorporate Risk Reduction Measures**	**Intolerable**
	☒	☒	☒	☐

Fig 5.2.2 Initial Risk Evaluation Result

Alternative ways to do the work:
N/A

Fig. 5.2.3 Initial Risk Evaluation: Alternative ways

4.1.6 Risk Evaluation Results and Risk Treatment

The results of the Initial Risk (IR) Evaluation concerning a possible collision with the approaching service vessel during an STS bunkering operation are presented below. It concerns the Company's People, Assets, Environment, and Reputation, and the initial risk is evaluated as per the company's Risk Assessment procedure. Moreover, the Risk Treatment to mitigate the risk will be presented in accordance with the Company's guidelines, to provide the **Residual Risk (RR) Evaluation**.

Consequences

1. **Structural Damage**

People - D2: Requires incorporating risk reduction measures.
Assets - D2: Requires incorporating risk reduction measures.
Environment - D1: No risk mitigation measures are required, but rather management for continuous improvement purposes.
Reputation - E2: Requires incorporating risk reduction measures.

2. **Pollution**

People - C3: Requires incorporating risk reduction measures.
Assets - C3: Requires incorporating risk reduction measures.
Environment - D3: Requires incorporating risk reduction measures.
Reputation - D3: Requires incorporating risk reduction measures.

3. **Fire/Explosion**

People - C5 **Intolerable Risk - Major Hazard Activity:** Requires incorporating risk reduction measures.

Assets - C4: Requires incorporating risk reduction measures.

Environment - C4: Requires incorporating risk reduction measures.

Reputation - C4 **- Major Hazard Activity:** Requires incorporating risk reduction measures.

4. **Injuries**

Personnel - D2: Requires incorporating risk reduction measures.

Assets - D2: Requires incorporating risk reduction measures.

Environment - D1: No risk mitigation measures are required, but rather management for continuous improvement purposes.

Reputation - E2: Requires incorporating risk reduction measures.

5. **Man Overboard (MOB)**

Personnel - C2: No risk mitigation measures are required, but rather management for continuous improvement purposes.

Assets C2: No risk mitigation measures are required, but rather management for continuous improvement purposes.

Environment C1: No risk mitigation measures are required, but rather management for continuous improvement purposes.

Reputation D2: Requires incorporating risk reduction measures.

Risk Treatment

The Risk Treatment *(Fig. 5.3)* presents the safeguards the Company will establish, which are additional actions to be taken following the initial risk assessment in order to reduce the risks relating to the activity/action assessed.

1. To mitigate the risk of structural damage happening to the ship, the Master or Chief Officer will continuously monitor the weather.

2. To mitigate the risk of Pollution, during the STS bunkering with an approaching service vessel, the Chief Engineer or Chief Officer will establish continuous additional watches.
3. To reduce the risk of a Fire or Explosion before commencement of the activity described, the Chief Engineer or Chief Officer will hold a work planning meeting with the people involved.
4. To mitigate the risk of Injuries, the Chief Engineer or Chief Officer will establish a continuous supervision of tasks by experienced crew.
5. Lastly, on a case by case basis, the Master will order the cease of operation if weather conditions worsen, to mitigate the risk of a MOB incident.

RISK TREATMENT							
Safeguards [5] (actions to be taken following the assessment)	**Responsible Person**	**Action Timeline**	**No.**	**Residual Risk Evaluation**			
				P	**A**	**E**	**R**
1. Weather monitoring	Master - C/O	Continuous	1	B2	B1	B1	C1
2.Additional watches	C/E - C/O	Continuous	2	B2	B1	B1	C1
3. Work Planning Meeting	C/E - C/O	Before commencement	3	B2	B1	B1	C1
4. Supervision of tasks by experienced crew	C/E - C/O	Continuous	4	B2	B1	B1	C1
5. Cease of operation in case of weather conditions worsen	Master	Case by case	5	B2	B1	B1	C1

Note P: People, A: Asset, E: Environment, R: Reputation

Fig. 5.3 Risk Treatment

Residual Risk Evaluation

The above additional actions reduce the risk, and after the new **Residual Risk (RR)** evaluation *(Fig. 5.4)*, no further risk mitigation measures are required, but only their management for continuous improvement purposes. After the implementation of the company's existing measures as well as the additional risk treatment, all risk ratings are now lowered to *Green* “manage for continuous improvement”.

Concerning the activity described, with the risk at an acceptable level, the necessary approval can be granted in order to proceed with the operation.

1. **Structural Damage**

People - B2

Assets - B1

Environment - B1

Reputation - C1

2. **Pollution**

People - B2

Assets - B1

Environment - B1

Reputation - C1

3. **Fire/Explosion**

People - B2

Assets - B1

Environment - B1

Reputation - C1

4. **Injuries**

People - B2

Assets - B1

Environment - B1

Reputation - C1

5. **Man Overboard (MOB)**

People - B2

Assets - B1

Environment - B1

Reputation - C1

RESIDUAL RISK EVALUATION RESULT	Major Accident Hazard	Risk Categories [7] (Tick as appropriate)		
		Manage for continuous improvement	Incorporate Risk Reduction Measures	Intolerable
	☐	☒	☐	☐

Fig. 5.4: Residual Risk Evaluation Result

Additionally, for continuous improvement purposes, the evaluator has to report whether any significant risks and training needs have been identified during the risk assessment, and after establishing the safeguards, whether there is a need to amend the company's SMS. Finally, the assessor has to report if a best practice has been identified for it to be established and followed by the Company's vessels. For this Risk Assessment some significant risks, and training needs have been identified as described previously.

Finally, the assessor has to include in the report the contingency plans that the company has in place to facilitate safe management and recovery of the situation in case of any unplanned occurrences. The assessor advises referring to the respective topics included the company's ship emergencies plan in cases of collision, fire onboard, injury and man overboard emergencies *(Fig.5.5)*.

Emergency Case:	**Contingency Plans:**
Collision , Fire onboard , Injury Man overboard	Refer to Company's Ship Emergencies Plan – Potential Emergency Situation: Collision , Fire onboard , Injury , Man overboard

Fig. 5.5 Emergency cases and contingency plans

Following the completion of the activity which was the subject of the risk assessment, the company can proceed to a further review of the results, to locate areas of improvement, additional measures required, or other conclusions drawn from the RA, that will ensure the continuous improvement and enhance security and safety of this operation.

To conclude, this case study investigating the HSQE Management System (HSQEMS) of a Greek tanker shipping company ("the Company"), verifies that the Company employs proactive and reactive strategies to manage health, safety, quality, and environmental risks, with a structured approach to hazard identification and risk evaluation. Key findings reveal that while structural damage is a minor risk, pollution poses significant threats, necessitating robust safeguards. The risk assessment process identified intolerable risks for explosions and significant risks for injuries and man overboard incidents, leading to proposed mitigation measures that successfully reduced residual risk ratings. The study concludes that the company's systematic risk management framework enhances operational safety and compliance, demonstrating a strong commitment to continuous improvement and emergency preparedness.

Chapter 5: Discussion

5.1 Disruption Cases Overview

The study of the disruption cases revealed a few lessons learned and recommendations that could be useful to the shipping community.

1. **Alternative routes & Onland transportation**

Suez' blockage disruption case highlighted the vulnerable nature of global trade routes. Companies realized that establishing alternative routes and suppliers was critical to mitigate any future risks associated with similar disruptions and strengthen resilience. The Panama and the War in Ukraine disruptions provided similar lessons learned, adding the significance of implementing onland transportation solutions and diverting on a proactive basis.

It is recommended that in anticipation and preparation for increasing disruptive events companies invest in these proactive and reactive strategies that help mitigate the risks stemming from congestion in critical passageways.

2. **Investing in advanced technologies**

From the Maersk, MSC and CMA CGM technology implementation cases, it is arguable that when companies invest and implement advanced technologies it can significantly enhance supply chain visibility and resilience, streamline procedures, and reduce unnecessary workload and delays. At the same time such technologies can help carbon emissions and help the company remain in-line with environmental protection policies and reach "green" goals.

It is recommended to invest in technologies to help increase efficiency and reach targets.

3. **Improved Risk Management and Contingency Planning**

From the Hanjin collapse case it can be deduced that effective risk management and contingency planning can assist in handling unexpected disruptions. This disruption case revealed the importance of the financial stability of a company for international shipping as well as the importance of companies having contingency plans in place to mitigate the effects of such disruptions effectively. It is recommended, in order to strengthen professional relationships, to develop risk management strategies, create contingency plans, and diversify partners. Additionally, assessing the financial health of both current and potential partners ensures informed decision-making and promotes sustainable engagements.

4. **Enhancement of Cybersecurity Measures**

The cyber-attacks against Maersk underlines that cyber threats are of significant risk for the shipping industry. This cyber-attack case demonstrated that digital infrastructure can be vulnerable and cause major disruptions to the company's operation. As a result, it is recommended that companies focus on implementing robust cybersecurity protocols, segregating operational and IT systems, and training personnel on cyber incidents.

5. **Sustainability and Environmental Considerations**

The Panama Canal drought case showed how environmental factors can have a major impact and cause disruptions in shipping, and at the same time highlighted the importance of embracing environmental-friendly solutions to contribute to green practices that have a beneficial effect on the environment. On a larger scale, companies are increasingly acknowledging the environmental challenges posed by shipping. It is recommended that actions are taken to optimize routes for improved fuel efficiency. Additionally, the use of alternative fuels should be considered, and investments in eco-friendly technologies should be made to align with environmental regulations and demonstrate a commitment to sustainability. These measures not only help in complying with regulations but also demonstrate a commitment to sustainable practices.

6. **Collaborative Approaches and Industry Partnerships**

Various types of disruptions (natural, man-made, technical or economic), which could result in port congestion, canal drought, new regulations, collapses etc. can be prevented or treated with collaborative practices across the industry to achieve quick recovery or reveal alternative solutions. Collaboration between shipping companies, port authorities, and governments has proven essential for quick recovery. Forming strategic partnerships and industry coalitions to share resources, information, and best practices can be beneficial for the shipping community.

7. Regulatory and Compliance Adjustments

IMO 2020 regulations highlighted the fact that adapting to changes in regulation is of imperative importance to avoid disruptions in operations, non-compliance issues, legal or financial repercussions, etc. Whilst the regulations might pose a high initial investment cost or additional costs, companies proceeded to the necessary actions to comply with the new regulations, prevent future incidents and turn this into a competitive advantage against competitors. Companies invest in new equipment and update their policies and procedures to ensure compliance. Remaining compliant to international rules and regulations is crucial for shipping's success and is always recommended.

5.2 Real-Life Risk Assessment Scenario Overview

Studying the real-life risk assessment scenario and the company's approach to it, it was determined that The Company uses its historical data on incidents/accidents and with the use of its qualitative risk analysis matrix in place, and the judgment of the adequately trained assessor, completes the risk assessment process. (a) The company has a Risk-Management system in place, including a Risk-Assessment procedure, in line with the requirements of international regulations. It was verified that (b) by following its established HSQMS the company identifies and records the possible hazards, measures the potential risk, and (c) applies the necessary safeguards to mitigate the risk. The company conducts the risk assessment for its people, assets, operating environment and reputation and treats the risk, rendering the residual risk at an acceptable level. For contingency planning purposes within the risk assessment procedure, the company makes mention of the relevant (d) contingency plan in case of emergencies. The company, in line with continuous improvement practices, (e) records new threats, enriching its RA Library. The Company has established (f) Indicators that, depending on the source of the barrier (technical barrier, human factor, barrier outside of the company's control) determine its quality. It is also determined that (g) the Company reviews the cost-effectiveness of the barrier which determines the barrier's acceptance.

The Company's structured approach to risk management demonstrated in real-life disruption case scenario, promotes the Company's operational safety and adherence to regulations, with dedication to continuous improvement and emergency preparedness.

5.3 Challenges in Disruption Management

The cases mentioned above showed that implementing effective disruption management strategies and technologies in shipping can be beneficial when managing risks, but still, there are implementations that can be challenging.

1. **Complexity and Cost:** Integrating new technologies like AI, IoT, blockchain and predictive analytics into existing systems can add to the company's costs and be quite complex to execute. As shown in the Cyber attack case, even major shipping companies rely on legacy IT systems. For a major player such as Maersk with hundreds of offices around the world it could be easily argued that implementing a new technology would be complex and costly. Moreover, as shown in the Blockchain case, sometimes companies find it too expensive to invest in a new technology or do not have incentives strong enough to justify the extra cost for its implementation.

2. **Cybersecurity Concerns:** Shipping's increasing reliance on digital services makes it at the same time vulnerable to cyberattacks. Companies will then have to implement robust cyberattack measures and invest in staff's training on handling cybersecurity matters. This increases the costs for a company. Increased connectivity (such as the use of IoT devices) increases the risk of cyber threats, like shown in the Maersk case, resulting in the disruption of the company's operation, and in other cases even the compromising of sensitive data

3. **Cultural and Organizational Resistance.** Introducing changes can be met with resistance which can make adopting strategies and technologies difficult. Lack of understanding or fear of job loss can make employees and management hesitant in adopting new technologies. Investing in the training and development of employees could make employees more receptive to change.

4. **Coordination Across Stakeholders** is beneficial but can be challenging to apply in a complex environment, as good coordination and collaboration must be accomplished

across various stakeholders. Also, using different communication systems and lack of trust and transparency due to the competitiveness of the sector can hinder coordination and collaboration initiatives.

5. **Regulatory and Compliance Issues.** Regulations can vary from one region to another. That makes compliance with them challenging, as constant monitoring and adapting to the changes is required. Furthermore, being compliant with a regulation can raise the costs and demand more resources (time, money, staff, etc.)

6. **Financial Constraints.** Investing in disruption management solutions, strategies or technologies, can come with a high financial investment and/or upfront costs, and the return of these investments cannot always be easy to justify.

5.4 Discussion Overview

Disruption management is a multifaceted and complex notion, which requires resilience, effective risk management, continuous improvement, and operational efficiency. This dissertation tried to identify contributing factors to disruption management and risk mitigation and help the shipping community face future challenges and maintain its leading position in global trade.

1. Compliance with Rules & Regulations.
2. Establishment of proactive and reactive strategies.
3. Robust risk management practices.
4. Investing in staff's training and capacity building.
5. Implementation of new technologies.
6. Management of change.
7. Review of existing procedures and material (i.e. Company SMS) for continuous improvement purposes.
8. Understanding and treating human-error associated risks (due to fatigue, understaffing etc.).
9. Leadership development: To build resilience, develop leadership programs focused on strategic thinking and resilience.
10. Adopting new technologies.
11. Investing in cyber-security measures.
12. Collaboration and communication across the shipping community.
13. Adequate insurance and financial planning.
14. The cost-effectiveness of each solution should be considered.

5.5 Limitations & Areas for Future Research

Limitations

This dissertation's main focus was on disruption management of events mainly affecting operational aspects and risks relating to the ship, the company, its personnel and the physical environment within which operations take place, inspired by the HSQE concept. This dissertation also focused on commercial shipping, excluding sectors such as cruise shipping and Ro-Ro/Ro-Pax, and on ocean-going vessels irrespective of their type, capacity, age, flag state, etc. Although this dissertation aims to provide a general approach of shipping disruptions and their management it occasionally references specific sectors like container shipping and bulk trade. Additionally, the study emphasizes operational, personnel, compliance, and HSQE-related aspects within the maritime domain, which may not be applicable to other shipping contexts.

Future Research

Future research can include an in-depth analysis of various risks beyond HSQE aspects, such as financial and business risks that could threaten shipping companies and their assets. As the focus of this dissertation was on ocean-going merchant vessels, future works can study disruption and risk management concerning other types of vessels such as passenger carrier vessels, Ro-Ro, or vessels sailing in other bodies of water such as rivers or lakes. Furthermore, future research could focus on the investigation of the cost-effectiveness of disruption management and risk mitigation measures used by the industry. Given the rise of digitalization and technology implementation in shipping, examining how technological failures may affect shipping and how emerging technologies can contribute to risk and disruption management could provide valuable insights. Future works could focus on the cost-effectiveness of disruption management and risk mitigation solutions.

At the time of writing of this dissertation there are ongoing developments in the Red Sea and Ukraine and future works could focus on their implications for global shipping and possibly, new risk treatment strategies and technologies that can be implemented. Lastly, the social consequences of unmanaged disruptions in shipping can be further examined in future works.

5.6 Conclusion

In conclusion, the study of recent disruption cases that impacted the shipping industry highlighted a variety of essential strategies and technologies to enhance resilience and manage risks. Key Findings of this dissertation include strategies and technologies such as establishing alternative routes and suppliers, investing in advanced technologies to improve supply chain visibility that can improve disruption management and mitigate the impact of risks. Implementing robust risk management practices, practicing contingency planning, and investing in technology and cybersecurity can help address threats and cybersecurity issues. Collaboration across industry stakeholders and adapting to regulatory changes can promote the sustainability of operations. Moreover, adequate insurance and financial planning are necessary to mitigate business risks. These elements and their strategic combination can benefit disruption management and address risks effectively.

This dissertation hopes to provide a comprehensive approach in understanding and addressing the complexities of disruptions in the shipping industry. For industry practitioners and researchers it hopes to provide insights and strategies that can be implemented to enhance resilience. This dissertation wishes to contribute to decision-making processes, and assist companies to safeguard their operations against unforeseen challenges.

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ANNEX A

Company's Guidance: Risk Assessment Matrix:

Severity	Consequences				Likelihood				
					A Rare	B Unlikely	C Remote	D Occasional	E Frequent
	People	Asset	Environment	Reputation	Not heard in industry	Has occurred once in the worldwide fleet	Has occurred once in the life of COMPANY's Fleet or occurs once per year in the worldwide fleet	Happens once a year in the COMPANY's Fleet	Happens once per year per COMPANY's Ship
1 Slight	Not affecting present work	No disruption to operations	Minor release contained on board. No environmental damage	No concern	[Green]	[Green]	[Green]	[Green]	[Green]
2 Minor	Minor Injury, lost time incident, reversible health effects incurred	Possible short disruption of operations (< 1 week), cost of repair less than $100,000	Contamination affecting immediate surrounding environment, minor response required to restore area (e.g. discharge < 10bbl, minor emission)	Internal concerns raised	[Green]	[Green]	[Green]	[Yellow]	[Yellow]
3 Significant	Permanent partial disability or significant irreversible health effect	Operations temporarily halted (< 1 month), estimated cost of repair less than $1,000,000	Significant environmental impact, significant measures required to restore contaminated environment (e.g. discharge < 100bbl, significant emissions)	Country (port, flag or owner) media coverage (paper, magazine)	[Green]	[Green]	[Yellow]	[Yellow]	[Red]
4 Severe	Single fatality, permanent total disablement / unfit for work	Partial loss of ship, loss of trading (~6 months), estimated repairs less than $10,000,000	Severe environmental impact, extensive measures required to restore contaminated environment (e.g. discharge < 1000bbl, severe emissions)	[Brown] Country (port, flag or owner) media coverage (TV, papers). Worldwide media coverage (papers, magazines)	[Green]	[Yellow]	[Yellow]	[Red]	[Red]
5 Major	[Brown] Multiple fatalities	[Brown] Extensive damage to ship, indefinite off trading, possible total loss of asset	[Brown] Long term environmental damage affecting extensive area and requiring extensive cleanup (e.g. discharge > 1000bbl, massive emissions)	[Brown] Worldwide media coverage (TV, papers)	[Yellow]	[Yellow]	[Red]	[Red]	[Red]

Major Accident Hazard	Risk Categories		
[Brown]	[Green] Manage for continuous improvement	[Yellow] Incorporate Risk Reduction Measures	[Red] Intolerable