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The ship-port interface safety management: case study of LNG ports and marine terminals in Algeria

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SHIP-PORT INTERFACE SAFETY MANAGEMENT: CASE STUDY OF LNG PORTS AND MARINE TERMINALS IN ALGERIA

by

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2022

Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

(Signature): **Benyebka CHERIGUI**

(Date): **September 20, 2022**

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" *Safety is not an intellectual exercise to keep us in work. It is a matter of life and death. It is the sum of our contributions to safety management that determines whether the people we work with live or die.*"

By Sir Brian Appleton,

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Abstract

Title of Dissertation: **The Ship-Port Interface Safety Management: Case Study of LNG Ports and Marine Terminals in Algeria.**

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LNG Ports and marine terminals are one of the essential components of the natural gas supply chain. Recently, their importance has risen as a result of the increased demand of LNG in the world. However, handling LNG cargo is very complex, exposing workers and the surrounding environment to hazards, particularly at the ship-port interface, the critical link where the highest number of LNG accidents occur. Algeria is a leading supplier of natural gas in the world. It was the first nation to export liquefied natural gas in 1964. However, Algeria's LNG ports and marine terminals date back more than five decades, thus requiring particular attention to the safety system applied to this infrastructure.

The purpose of this study is to understand the ship-port interaction in Algerian LNG terminals with respect to safety of operations. It aims to identify the potential hazards and the related factors jeopardizing safety and propose safety management recommendations. Moreover, this study will attempt to provide evidence of the necessity of establishing an international tool for safety management at the ship-port interface, aiming to contribute to safety improvement in the port sector.

In this research, a mixed method was applied, simultaneously combining a quantitative and qualitative approach, using a questionnaire survey and semi-structured interviews. Based on risk management standard ISO 31000:2018 and the literature review, the researcher has established a conceptual framework as a road map to guide this research. This generated five safety management-related factors, including a) safety of operations, b) leadership safety commitment, c) safety communication, d) safety training, and e) safety improvement. A thematic analysis was used to analyse qualitative data, and the Statistical Package for the Social Sciences (SPSS) assessed quantitative data, i.e., correlation, regression, and factor analysis.

The findings concluded that safety management at the ship-port interface is highly linked to the abovementioned factors. Therefore, there is an immediate need for a new paradigm that blends leadership and safety commitment, active communication, efficient personnel training, and ongoing improvement to enhance safety in Algerian LNG ports and marine terminals.

KEYWORDS: Safety management, LNG terminals, Ship-port interface, LNG, Risk management.

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Abbreviations

BSI	British Standards Institution
CEE	Central and Eastern Europe
CEN	the European Committee for Standardization
EFSA	The European Food Safety Authority
ESDS	Emergency Shut-Down System
FSA	Formal Safety Assessment
GDP	Gross domestic product
HSE	Health Safety and Environment
IAPH	International Association of Ports and Harbors
IGC Code	International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk
IGF Code	International Code of Safety for Ship Using Gases or Other Low-flashpoint Fuels (IGF Code
ISM Code	International Safety Management Code
ISPS Code	International Ship and Port Facility Security Code
ISGOTT	International Safety Guide for Oil Tanker and Terminals
ISO	International Organization for Standardization
IchemE	Advancing Chemical Engineering Worldwide
ICS	International Chamber of Shipping
IMO	International Maritime Organization
IRGC	International Risk Governance Council
LNG	Liquefied Natural Gas
OPEC	Organization of the Petroleum Exporting Countries
MAIB	Marine Accident Investigation Branch
MTIS	Marine Terminal Information System
MTMSA	Marine Terminal Management and Self-Assessment
OCIMF	Oil Companies International Marine Forum
PIANC	The World Association for Waterborne Transport Infrastructure
SMS	Safety Management System
SPSS	Statistical Product and Service Solutions
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
SIGTTO	The Society of International Gas Tanker and Terminal Operators
UH IELE	University of Huston Institute for Energy, Law and Enterprise

Chapter 1: Introduction

1.1 Background

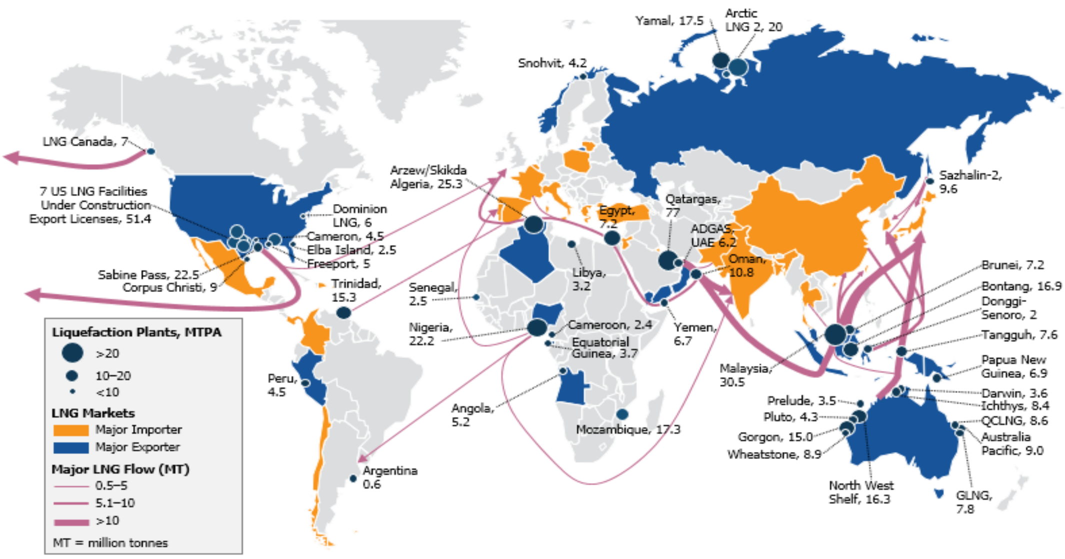
Ports are critical links in the global marketplace (Becker et al., 2013; Nagi et al., 2017; Wang & Cullinane, 2006), as they serve as the interface between land and sea. Ports are not only a component of the supply chain but also a critical trading centre for international shipping, including logistics, leisure, and energy (Nagi et al., 2021). Despite the most severe crises, such as the recent COVID-19 crisis, ports remained at the frontline of international logistics, ensuring an uninterrupted supply of medical products around the world, including food, energy and materials (UNCTAD 2020). Over 80 per cent of international trade flows through the ports. (UNCTAD, 2021). According to Statista, in 2020, the estimated volume of maritime commerce handled in worldwide ports was around 11 billion tonnes (Statista, 2021). This volume is expected to increase as the international seaborne trade revives and rebounds from the COVID-19 pandemic shutdown (Drewry Maritime Research, 2021).

The ports encompass all the activities related to carrying, handling, and storing goods (Gharehgozli et al., 2016), involving several actors, such as pilots during vessel entrance and departure, including towage and mooring services. In addition, the freight is handled by a terminal operator, who guides them to storage facilities before its delivery to the hinterland (Dwarakish & Salim, 2015). However, due to their various operations, ports are complicated entities with considerable source of high-risk accidents (Darbra et al., 2005; Ronza et al., 2003). In addition, the ship-to-port interaction generate hazards that may directly impact the port operations, causing unwanted events such as accidents and incidents, resulting in harm to individuals, facilities, and the environment, as well as delays to services (Nagi et al., 2017). According to Darbra et al. (2005), the most significant involvement in terms of accidents in ports by far is loading and unloading of goods, followed by port manoeuvring operations, representing 41% and 23%, respectively. As a result, safety management at ports is crucial in preventing unexpected disasters, particularly at ship-port "interface," which is a distinguishing feature of ports and considered the most critical transfer link in the maritime supply chain.

The global port industry dates back to the earliest times. It has grown significantly since then. Although cargo-handling techniques remained difficult and hazardous until the 1960s, they have become more sophisticated and improved in performance (ILO, 2016). Despite the fact that several ports continue to use multifunctional facilities, similar to ships, contemporary port structures and operational systems are geared to accommodate a specific type of commerce, vessel, or freight (Bichou, 2014), such as LNG port and marine terminals, which are specialised facilities inside ports.

LNG ports and marine terminals are a fundamental element of the natural gas distribution supply chain. They are constructed at port area for loading and unloading Liquefied Natural Gas (LNG), including its liquefying to approximately -161 °C before being transported via an LNG tanker or other gas transportation network (Hu et al., 2021). In recent years, the importance of this kind of infrastructure has risen, as a result of the attractive pricing in the marketplace and the environmental features of LNG (Vianello & Maschio, 2014), as well as, economic sustainability while also reducing carbon emissions (Y. Li & Xia, 2013). In 2021, the worldwide trading volume of liquefied natural gas reached 516 billion cubic meters. The statistics climbed by 513 billion cubic metres between 1970 and 2021. Australia was the world's largest exporter of LNG in 2021, with a total export volume of 108 billion cubic metres. Meanwhile, China was the largest importer of LNG, purchasing approximately 109 billion cubic meters (Statista, 2022). (Figure 1: refers to worldwide export and import countries in 2021).

Figure 1 *LNG Export & Import Countries 2021*



Note. (Incorrys, 2021)

Similar to any other industry, natural gas activity is not exempt from accidents due to its combustible and explosive properties. Thus, any accident may have severe repercussions for the safety of individuals and facilities, including the surrounding environment. As was recently shown, the explosion and fire at the Freeport LNG export terminal in Texas on June 8, 2022, resulted in the closure of the facility, causing a loss of 2 billion cubic feet of LNG daily in terms of export, affecting international LNG supply as several countries aim to wean themselves from Russian gas. Therefore, it is crucial to perform research to establish the potential reasons and situations for these failures, notably in the LNG transportation sector (Hidalgo et al., 2013; Cheng et al., 2009), mainly the ship-port interface, which encompasses the complicated LNG cargo transfer operations process.

In contrast to the port industry, in the shipping sector, since its foundation, in 1958, the International Maritime Organization (IMO), a specialized agency of the United Nations has focused chiefly on safety-related concerns in the maritime sector (Moore & Roberts, 1995). As a result, around 50 conventions and protocols have been adopted, including codes and recommendations (Vidas & Schei, 2011). Also, in order to strengthen the safety of LNG in the shipping industry, a number of instruments, standards, guidelines, and best practices have been developed. The most essential are obligatory provisions established by the IMO, including the Convention for the Safety of Life at Sea (SOLAS), the International Code for the construction and equipment of ships carrying liquefied gases in bulk (IGC Code), the code of safety for ships using gases or other low-flashpoint fuels (IGF Code), the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW), and the International Safety Management (ISM) Code (Koromila et al., 2022; Aneziris et al., 2020). However, in general, there appears to be a lack of international mandatory safety management guidelines or code in the port industry, for the reason that the ports, including terminals are considered part of state sovereignty and generally covered by local rules and national legislation, contrary to shipping, which is international.

Recent research shows that implementing the ISM Code has enhanced maritime safety and decreased human-caused shipping accidents (Tzannatos & Kokotos, 2009;Tzannatos, 2010). As a consequence, the Oil Companies International Marine Forum (OCIMF), which is known as the oil sector's voice, offering expertise in terms of safety and ecological handling and carriage of hydrocarbons in tankers and terminals, with collaboration with other organizations promoting the safe and sustainable carriage of oil products, such as the Society of International Gas Tanker and Terminal Operators (SIGTTO), the International Chamber of Shipping (ICS), the International Association of Ports and Harbors (IAPH), developed multiple voluntary guidelines and tools for the safety of oil tankers and LNG terminals (OCIMF, 2021). However, these voluntary guidelines and tools remain inapplicable rigorously to most LNG terminals for the reason that OCIMF does not have the authority to enforce its standards as an International Maritime Organization (IMO) created for this purpose. Moreover, developed nations such as the United States, Australia, the United Kingdom, Ireland, and New Zealand, port authorities have chosen to take advanced measures in setting codes and guidelines specific to port safety management systems, recognizing that the range and complexity of port activities are distinguishable from those of other sectors (Antão et al., 2016; Kadir et al., 2017b).

Nevertheless, in 2004, the enforcement of the International Ship and Port Facility Security (ISPS) Code succeeded, particularly in terms of risk mitigation concerning security incidents affecting port facilities, notably the ship-port interface.

The diverse character of port governance and the multiplicity of local laws make global port and terminal regulation a challenging game. So, how can a global safety management tool contribute to addressing safety challenges in ports and terminals by taking into consideration the adoption of the ISM Code on board vessels?

1.2 Problem Statement

Ports are one of the most essential components of the maritime transport chain and the essential way of connecting to the global economic system, as well as a multiple transport mode (warakish & Salim, 2015). Ports include different facilities and terminals where a large variety of activities are performed, including handling dangerous products such as liquefied natural gas (LNG), which is a highly complex process. These expose employees and the environment to hazards, particularly at the ship-port interface, which is considered a junction point of goods transfer from ship to terminal. Therefore, understanding the ship-port interaction in LNG terminals with respect to cargo operations will help detect possible high-risk threats and the related measures and enhance the safety management efficiency in this critical area. Eliminating such risks contributes to protecting the environment, public health, and business sustainability (Tseng & Pilcher, 2017; Alamoush et al., 2021). When considering the above statement, the following question arises: Why are serious accidents frequent at the ship-port interfaces during port operations? Furthermore, could establishing an international safety management tool be an effective solution to enhance port safety?

1.3 Objectives and Research Questions

The present study’s goal is to enhance port safety, particularly the ship-port interface in LNG terminals. It aims to identify the frequent threats leading to accidents during port operations with regard to ship-port interaction through the analysis of accidents that occurred in the past. Taking the case of LNG terminals in Algeria. The challenges in terms of safety management will be the aim of analysis and discussion, focusing on harbour master and port safety stakeholders’ feedback. Moreover, this study will try to provide evidence of the necessity of establishing an international tool for safety management in ports to enhance port safety on a global scale. The three research questions below are used to explore the study goals.

1. What are the threats jeopardising safety in LNG ports and marine terminals with regard to the interface between ship-port?
2. What are the factors attributed to accidents/incidents in Algerian LNG terminals, particularly in the interaction between ship-port operations?
3. What are the challenges and the prospects to enhance the ship-port interface safety management in Algerian LNG ports and marine terminals?

The final result should be a comprehensive grasp of the importance of safety management tools and how they help people perform better. This research intends to provide the reader with a better understanding of the significance of safety management tools in enhancing safety performance.

Chapter 2: Literature Review

2.1 LNG Characteristics and Associated Hazards

LNG is liquefied natural gas as a cryogenic liquid with an estimated temperature of -162 °C. It is flammable between 5 and 15 per cent by volume (Vanem et al., 2008). Owing to its broad explosion limit range, its high gasification ratio, and severe accident effects, the United Nations classifies it as a flammable gas category (2.1) under UN number 1972 (ONU, 2019). According to research published (UH IELE, 2003), LNG is not only odourless, colourless, noncorrosive, and nontoxic but also less dense than water. LNG liquefaction generates a liquid 600 times less voluminous than natural gas in the ambient atmosphere, which makes its transport most cost-effective over long distances via LNG ships built and developed for this purpose ((Moon et al., 2009). (Table 1 refer to LNG properties)

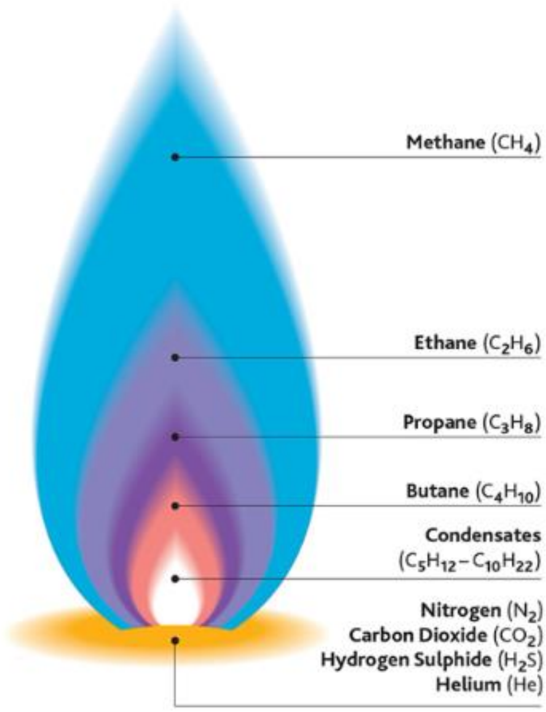
Table 1 *Properties of LNG*

Properties	LNG
Toxic	No
Carcinogenic	No
Flammable vapour	Yes
Forms vapour clouds	Yes
Boiling point	-160 °C
Flammability range in air	5 to 15 %
Extreme cold temperature	Yes
Other health hazards	None
Flash point*	-188 °C
Stored pressure	Atmospheric
Asphyxiant	Yes, but in a vapour cloud
Behaviour if spilled	Evaporates as visible clouds, parts of which could be flammable or explosive

Note. Foss, M. M. (2012). Introduction to LNG: An overview on liquefied natural gas (LNG), its properties , the LNG industry , and safety considerations. June, 1–36.

As Figure 2 shows, LNG consists primarily of methane (CH_4), and other substances, such us ethane (C_2H_6), propane (C_3H_8), butane (C_4H_{10}), nitrogen (N_2), carbon dioxide (CO_2), including other complicated sulphur compounds (Mokhatab et al., 2013a), which must be removed before the liquefaction process (IChemE, 2007). However, according to the gas's origin and processing history, the natural gas's chemical composition differs from region to region.

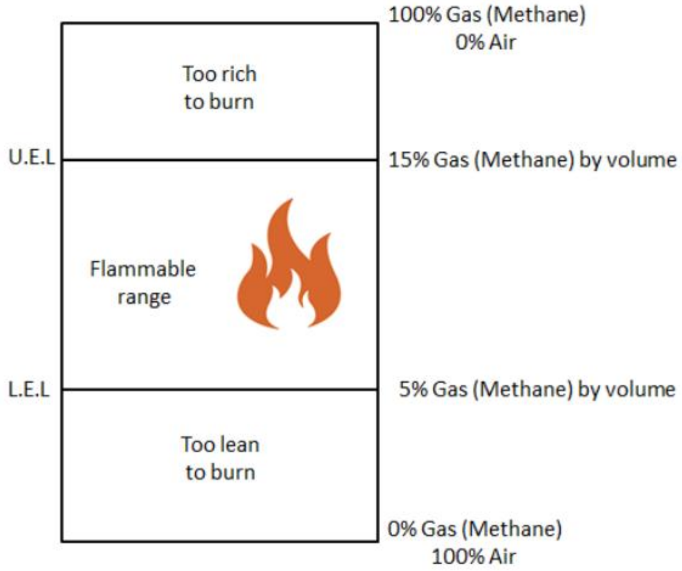
Figure 2 *Natural Gas Composition*



Note. Canadian centre for energy information.

As a result of natural gas flammability's, detailed in figure 3, an accidental release of LNG creates a threat of a fire or explosion in confined areas. The extremely cold temperature of LNG also causes risks. The probability and severity of LNG catastrophes have been the subject of debate, and there are still uncertainties about the reality of the effects of specific LNG threats, there seems to be unanimity regarding the gravest hazards (Parfomak & Flynn, 2004).

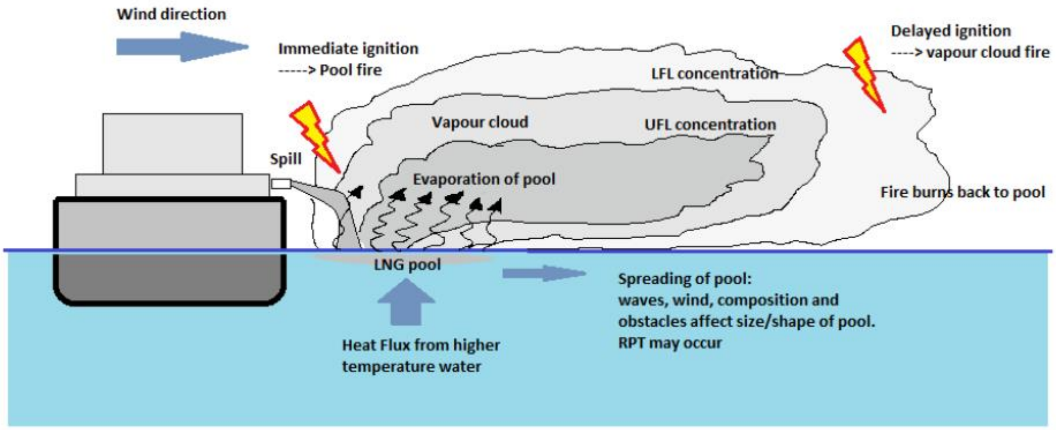
Figure 3 *Flammable range for methane (LNG)*



Note. (Bin Abu Bakar et al., 2019)

Several studies on LNG hazards, have been conducted. These studies have grown in recent decades. Literature on LNG safety hazards including Animah and Shafiee (2020), Aneziris et al. (2020), Aneziris et al. (2014), Mokhatab et al. (2013), Nwaoha et al. (2011, 2013), CEE (2012), Woodward and Pitbaldo, (2010), Brown et al. (1983); Ditali & Fiore (2008), CEE (2006), Sandia (2004), Walker et al. (2003) and Brown et al. (1983) states that principal hazards of LNG are fire and explosion, which might arise as a result of leaks and spills. These may present several possible threats scenarios, in the event of ignition, such as vapour cloud flash fire, jet fire, pool fire, and vapour cloud explosion. Figure 4 below summarizes the different possible scenarios that can happen as a result of LNG release.

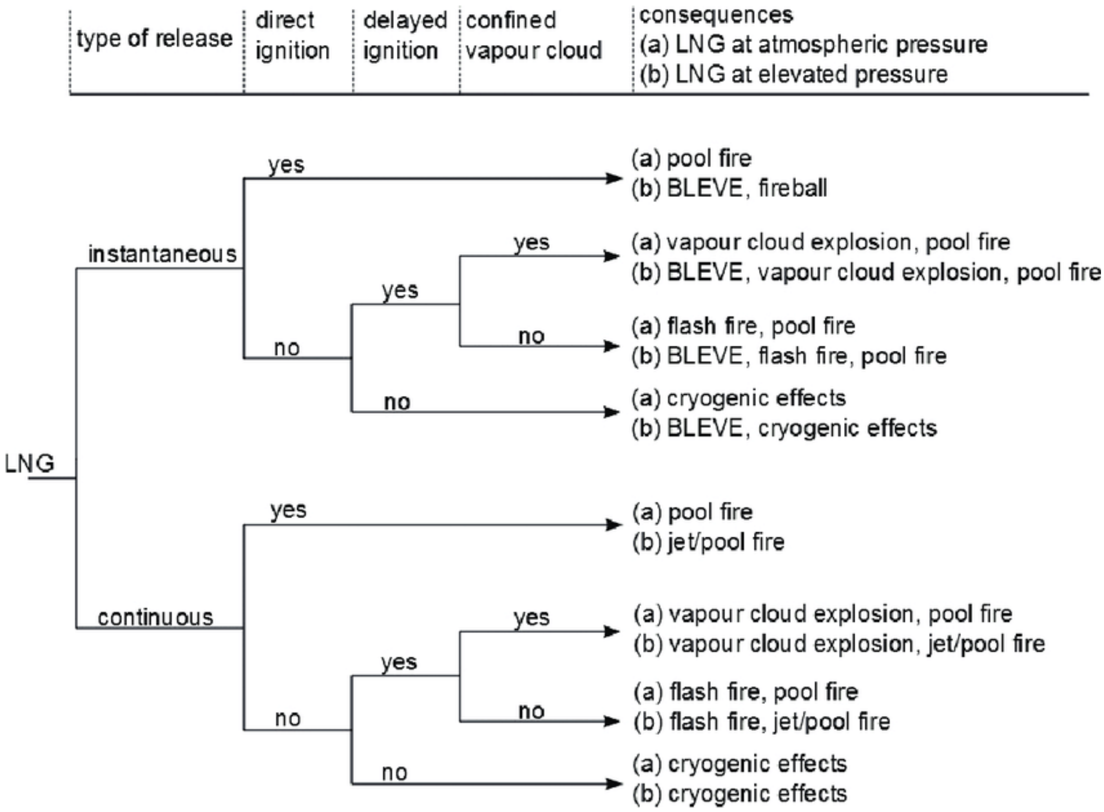
Figure 4 *Potential Fire Scenarios when LNG is Spilled on Water*



Note. (Luketa-Hanlin, 2006)

Walker et al. (2003) further emphasized that despite the LNG sector's strong safety reputation and rigorous design requirements for ships and terminals, it is impossible to expect what would occur in the event of a significant uncontrolled leak of LNG into the sea. As shown in the LNG release event tree in Figure 5, the fire's repercussions depend on the kind of LNG release, ignition, containment level, and operational pressure (Woodward & Pitbaldo, 2010; Brown et al., 1983). Also, as highlighted by Pio and Salzano (2019) and Pio et al. (2019), the effects of LNG fires and explosions rely on the LNG composition and temperature including the size of the pool fire.

Figure 5 *LNG Release Event Tree*



Note. (Ramsden et al., 2015)

Yoon (2006) emphasise also the phenomenon of rollover, which is related to the fast discharge of LNG vapour following the spontaneous mixture of strata of LNG with varying densities in a storing tank. This hazard may cause fissures or other structural damage.

LNG Masterplan Consortium (2015), recapitulated and defined the different LNG hazards as outlined in Box 1.

Box 1 *Hazards of LNG*

Vapour Releases. LNG release at atmospheric pressure leads to the formation of a pool, which first evaporates rapidly owing to the land and water's heating impact. A release of vapour from an atmospheric tank could cause the creation of a pool, with the rate being proportional to the magnitude of the vapour release. The discharge from tanks with increased pressures or temperatures would consist of 17% pressure release and the other 83 % as a pool.

Pool Fires. In the case of gas vapour ignition above the LNG pool, the LNG will be burnt at various rates according to whether the pool is on land or water. Because of the absence of soot deposits in the combustion, the warmth concentration is considerably greater than that of other fuels, especially at the starting point of the pool fire emergence, resulting in the possibility of fire spreading to nearby equipment through the heat emanating from the flame.

Flash Fires. A flash fire ensues when vapours from an immediate or continual release drift downwind to a source of ignition. When the fraction between the lower and upper flammable limits (LFL / UFL) detects an ignition source, the flames will spread through the cloud, attaining speeds of 10 to 12 m/sec if the vapour cloud is not constrained or in a densely congested environment. This kind of fire is known as a flash fire because the ignition flashes back to its source pool or point release.

Jet Fires. A jet fire happens when a pressured gas or liquid discharge generates an ignitable vapour cloud. If somehow ignition of the vapour cloud, flames will spread back to the source, but a jet fire will develop from the point of pressured release. The heat intensity is more than 300Kw/m2. A jet fire may have devastating consequences for the facilities if the flame comes into contact with poorly insulated equipment. Exposed steel will fail quickly and escalate the scenario further. Single-skin LNG pressure tanks are susceptible to jet fires; containment failure would result in the abrupt discharge of vaporised gas and a fire “BLEVE”.

Vapour Cloud Explosions. As previously explained, the release of LNG can swiftly produce an ignitable vapour cloud. In the event of a delay in igniting and the cloud is in a confined or densely obstructed environment, the resultant flame spread will accelerate speed toward the point where it causes overpressure and explosion damage.

BLEVE. A BLEVE incident happens when an LNG tank bursts dramatically under high pressure, usually due to flame impingement (jet fire) or technical damage to the tank's containment component. The consequent reduction in pressure and ignition of the enormous vapour release causes a Boiling Liquid Growing Vapour Explosion “BLEVE”, also known as a fireball, and accompanying impact damage

Rapid Phase Transition. In addition to the scenarios detailed above, a leak of LNG into the water may also cause a rapid phase transition (RPT). An RPT is a physical explosion resulting from the sudden boiling of LNG in direct contact with heated water. Since the overpressures induced by an RPT are restricted to the local area of the discharge, this hazard scenario is often neglected when considering the external human hazard. Analyses showed that this event might occur when the water temperature is between 12 and 17 C, and there is a lower methane concentration in the cryogenic mixture. Recent incidents have revealed that an RPT may also happen when warm gas is injected into a pipeline holding LNG.

Asphyxiation. An asphyxiation is a situation in which the body is significantly deprived of oxygen due to irregular respiration. It results in widespread hypoxia, affecting mainly the organs and the tissues. Asphyxiation may be caused by various conditions, defined by an individual's prolonged inability to get adequate oxygen via respiration. It may result in unconsciousness or fatality. Methane is an asphyxiant and can substitute oxygen in closed areas. Asphyxiation may happen if the oxygen level falls below roughly 16% owing to displacement, while the majority of individuals can withstand a decline from 21% to 16% without experiencing adverse consequences. The range of methane levels where the asphyxiation danger is considerable is far greater than the 5–15% concentration level seen in flammable or explosive mixtures.

Cryogenic Effects. LNG tanks are meant to prevent LNG from touching the inner and outer hulls, although events may enable such a situation. A discharge of LNG to the inner hull might cool parts of the structure that are not suited for cryogenic temperatures. As a result, the international regulations related to ship-design mandate that locations where cargo tank leaking may be envisaged must be resistant to cryogenic LNG contact.

Note. (LNG Masterplan Consortium, 2015).

2.2 LNG in Maritime Transport

Gas liquefaction is not recent. Michael Faraday, a British chemist, liquefied methane in 1854, and German engineer Karl Von Linde built the first compressor refrigeration system in 1873. The first LNG facility was developed in the USA in 1917, and the first commercial liquefaction facility opened in Cleveland, Ohio, in 1941, allowing long-distance natural gas delivery. In 1959, we saw the first maritime conveyance. The "Methane Pioneer" was a converted "liberty" freighter. This experiment showed that LNG might be safely delivered in significant volumes. LNG shipping began in 1964 when British Gas bought gas from Algeria. Fifty- eight years ago, Methane Princess and Methane Progress began shipping LNG cargoes from Algeria to the UK (SIGTTO, 2014).

In recent years, the liquefied natural gas (LNG) business has expanded significantly. Numerous LNG terminals have either been constructed or are already in the progress or planning stages (Stanković et al., 2018). Moreover, LNG vessels have met worldwide demand (Moon et al., 2009). Considering the current Ukraine War (2022) and the situation that has affected practically every EU country linked to a permanent gas pipeline with Russia, it is evident that LNG maritime transport is very important (Gucma & Mou, 2022). Figure 6 recapitulates 2021 flow trade worldwide.

In terms of the environment, natural gas is an eco-friendly, clean energy source that provides significant ecological advantages over other fossil fuels (Mokhatab et al., 2006; Pospíšil et al., 2019). It is also seen as a gateway fuel for achieving Sustainable Development Goals (SDG7), including the Paris Agreement target. On the other hand, IMO is encouraging investment in LNG-fuelled ships and bunkering port facilities, as shipping is a crucial factor contributing to climate change (Lister et al., 2015), due to the fact that 90 per cent of world commerce is transported by sea (Kaluza et al., 2010). As a result, rising numbers of vessels, are being constructed or adapted to use liquefied natural gas (LNG) (Allianz Global Corporate & Speciality, 2022). According to Roussanoglou (2021), during the year 2021, about 82 new LNG ships were ordered, compared to only 34 in 2020.

Although LNG has a number of advantages, it may cause severe hazards, especially when it is handled under dangerous circumstances in port and marine terminals, where the transfer of vast volumes of LNG can have significant repercussions (Yun et al., 2009). Maritime transport is indeed the safest phase of the supply chain, as indicated by the number of maritime casualties in the past decades (Perkovic et al., 2012; Gucma, 2007; Vidmar, 2014). However, despite the LNG sector's exemplary safety, the risk associated with LNG terminals could rise as the LNG industry grows (Yun et al., 2009). Therefore, understanding the LNG activity-related measures helps detect possible high-risk threats and may improve the safety of operations.

2.3 LNG Ports and Marine Terminals and Associated Hazards

LNG port and marine terminals are facilities for receiving LNG ships and discharging their cargo. These infrastructures are constructed specifically for the export and import of LNG. It offers LNG unloading, regasification, tanking and distributing. After unloading from ships, LNG terminals return the liquefied natural gas to its gaseous condition "regasification" before distributing it through other means of transportation (Hu et al., 2021), and vice versa during export process. LNG terminals are often located in the port area. They include a berthing zone with a pier or jetty and special arms for loading and discharging, a storage space, and a compartment for vaporization (Figure 6 refers). This design has been in operation for decades, and several facilities that are still functioning were constructed in the 1960s (Tugnoli et al., 2012)

Figure 6 *Costa Norte LNG Terminal, Colon*

Note. Adapted from official website of Hydrocarbons Technology (https://www.hydrocarbons-technology.com/)

LNG ports and marine terminals are vital to the natural gas supply chain process. This infrastructure's relevance is growing (Vianello & Maschio, 2014). It provides significant benefits compared to pipelines system, which have greater financial costs and less adaptability regarding geographical placement and security of supply (Calderón et al., 2016). Considering the estimated rise in the number of LNG carriers transiting across producing and consuming countries, and given the particular threat of LNG due to its extremely low temperature, the repercussions of an event involving LNG terminals will be disastrous. In addition, destruction or damage to a such facility might reduce LNG supplies and affect natural gas flow. Hence, measures to assure the safety and dependability of present or future LNG facilities and LNG shipping are essential from community safety and property protection viewpoints, including regional energy dependability (Sandia, 2004).

The hazards involved in LNG ports and marine terminals are similar to those mentioned above. However, they are mostly related to the interaction between ship and terminal, especially during cargo operations, including hazards arising from mooring arrangements. Morosuk et al. (2017) underlines the significant hazards during LNG cargo operation when tankers are moored in LNG terminals, these include:

- Leakage of LNG transferring pipes and valves on both the ship or shore side;
- Destruction of the transfer arms as a result of a failure in keeping the ship in position at berth, such as failure of a ship's mooring ropes; or jetty mooring equipment;
- Safety moving zone not applied resulting in movement of other ships closer to an LNG carrier in operation.

Moreover, ISO (2010) highlighted the vulnerability of cargo handling process to the following hazards and recommended to the involved parties in LNG terminals to take appropriate measures to avoid them. These hazards are associated with:

- Mooring failure;
- Inappropriate cool-down or warm-up operations, including emptying and purging of transferring arms;
- Tank overfilling caused mainly by the human element during handling operations;
- Emergency release coupling failure; and
- Hazards related to over-and under-pressurization.

The first LNG tanker "Methane Pioneer" commissioned on January 25, 1959 had only 5034 tons of deadweight. She was still a small vessel by today's standards. However, strong demand and competitive advantages in LNG large volume shipping also increase the size and alter the characteristics of LNG tankers (Starosta, 2007). LNG shipping has undergone a significant transformation. The fast increase in terms of ship design and size, today's largest LNG carriers are "Q-Max" and "Q-Flex" types, with a total length of 345 meters and a loading capacity of 266,000 cubic meters, equivalent to approximately 162,000 million cubic meters of natural gas (Nas et al., 2015), permitting substantially significant cargo volume transfers has generated new technological and operational issues at the port and terminals area (Unidas & Nations, 2020). However, despite the development of modern vessel and cargo handling technologies with a significantly expanded capacity and reach, enhancement of workers' and operations' safety, other modifications have created novel hazards both on board and ashore. As a result, the port sector is still seen as an activity with significant accident frequencies (ILO, 2016), particularly in LNG terminals, throughout ship-port interaction, where cargo transfers are very complex, including the distinctive feature of LNG, which could indeed cause serious accidents; leading to injuries fatalities, and destruction as well as loss of cargo, ships, and properties (ISO, 2015; Park et al., 2018).

2.4 The Ship-Port Interface and LNG Cargo Operations

The term "interface" corresponds to the port as the source of the necessary facilities and services for transferring cargo from vessel to shore, and inversely, the term "interface" was chosen because it evokes the idea of a point of connection between several forms of transportation (Adeyanju, 2014).

The ship-port interface in LNG marine terminals is an essential node in the LNG logistics system. It covers berthing, loading, and unloading process. LNG marine terminals are designed to accommodate LNG tankers with particular specifications and cargo capacity, owing to the different fender, and mooring systems utilized for LNG carriers of different sizes (Gucma et al., 2019). In addition, cargo loading and discharging processes at port and LNG terminals are more complicated than those of conventional ships. There are several parties involved in LNG handling, including companies, national and international entities, and people. They are charged with assuring and managing safety in all port facility operating circumstances (Alaba et al., 2016). Negligence in taking appropriate measures throughout LNG cargo operations might have negative results. The operation's safety and efficiency must start with a comprehensive awareness of the procedures required to prevent threats as well as system malfunctions. Therefore, planning LNG cargo operation is a very critical step, including gathering information and conducting a ship-to-port compatibility study prior to an LNG carrier visiting a terminal.

Despite recent attempts to design harmonization, ports and marine terminals continue to be distinct. Newly constructed tankers are restricted to calling at a maximum number of LNG terminals worldwide. Therefore, collected data must be consistent, changes must be monitored carefully, and communication between the terminal and the ship is vital to eliminate possible incompatibilities and needless delays.

Furthermore, prior to commencing cargo operations at the LNG terminal, the loading arms must be connected, pressurized, purged, and secured, including checking the safety systems (Alaba et al., 2016). Therefore, terminal managers need to operate in accordance with industry standards, as through Marine Terminal Management and Self-Assessment Guidance (OCIMF, 2012a). On the other hand, conducting an inspection, such as a screening process or vetting to confirm that the condition of the vessel is adequate for cargo transfer at the terminal (ISO, 2010), and guarantee the safety of operation.

According to McGuire and White (2000), in LNG terminals, the ship-port interface involves pre-planning and managing procedures so that both the ship and port are conscious of their responsibilities, capabilities, and constraints. Across the operations of cargo transfer, collaboration between ship and port is critical. Therefore, understanding the LNG activity-related measures helps detect possible high-risk threats and may improve the safety of operations (Alaba et al., 2016),

Liquefied natural gas is loaded into the LNG tankers through the strong liquid arms using submerged pumps from the shore side. The loading rate is raised gradually during the transfer operation to prevent pressure spikes in the ship and shore pipeline, including high vapour production in the ship's tanks during the first loading phases. The LNG-displacing vapour in the ship's tanks is returned to the terminal through a distinct vapour arm and pipe. The rate slowly decreases toward the completion of the loading until the last tank is filled. A high-level alert protects the ship's tanks from overfilling by immediately closing the filling valve of the relevant tank. The ship's tanks are also equipped with an alarm that, whenever detected, will activate an Emergency Shut-Down System (ESDS) and suspend the cargo transfer immediately. The same principles are followed during the unloading operation using the ship's tank submerged pump. However, the cargo vapour needed to restore the discharged LNG in the ship's tanks is usually provided by a separate vapour arm from the discharging terminal (IChemE, 2007).

Similar to LNG cargo handling, LNG bunkering from the terminal involves the same techniques and procedures and generate the same threats and hazards. Thus, high safety awareness is required for this activity (Jeong et al., 2017). Accordingly, bunkering transfer is not granted sequentially with LNG cargo operation except specially authorized by the port authority. However, it is recommended to undertake it before the commencement of cool-down or after the accomplishment of the cargo handling operation (ISGOTT, 2020).

The safety and dependability of LNG cargo operations are of the utmost importance to ports and operators. In addition to closure and supply failure, LNG hazards have a significant financial effect. Throughout the past decades, the LNG sector has progressively expanded and improved its procedures and practices, attaining excellent outcomes. According to UH IELE (2003), LNG could continue to be used long-term safely since sector technical standards, regulatory requirements, layout, and technologies are sustained and enhanced.

2.5 Ship-Port Interface Regulatory Framework

With the rapid expansion of the worldwide LNG trade, the regulatory framework for LNG terminals and shipping has recently been developed on a global scale. Various rules, standards, guidelines, and best practices have been developed to improve safety in LNG terminals (Aneziris et al., 2020a). In this study, the researcher reviewed compulsory regulations, current guidelines and standards, including the best practices for the ship-port interface.

In fact, LNG carriers' safety is governed by international regulations, which have been established by international specialized organizations, such as the International Maritime Organization (IMO). However, LNG ports and marine terminals are not regulated globally. As a result, national and local regulations are usually implemented, in a different way from one region to another. For instance, in the United States National Fire Protection Association 59 A (NFPA) standard is used for the Production, Storage, and Handling of Liquefied Natural Gas, the Health and Safety

Executive (HSE) in the United Kingdom, the Japanese Safety Bureau (JSB) in Japan, European Committee for Standardization (CEN) Standards and Directives in Europe.

The regions devoid of national rules, terminals are built and operated in accordance with globally recognized guidelines from Oil Companies International Marine Forum (OCIMF), World Association for Waterborne Transport Infrastructure (PIANC), Society of International Gas Tanker and Terminal Operators (SIGTTO), International Association of Ports and Harbors (IAPH), British Standards Institution (BSI), International Standardization Organization (ISO), and International Chamber of Shipping (ICS).

The most essential regulations applicable to ship-port interface are the mandatory requirements issued by the International Maritime Organization (IMO). This include the convention for Safety of Life at Sea (SOLAS) 1974 and its amendments, the International Code of the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code), the international Code of Safety for Ship Using Gases or Other Low-flashpoint Fuels (IGF Code), the Seafarers' Training, Certification and Watch-keeping (STCW) code, and the International Safety Management (ISM) code. In addition to the European Directives, 2012/18/EC, commonly called as "Seveso III," is of great relevance (Directive, 2012), and the ISO standards, such as ISO 28640:2010 and the guidance ISO/TS 16901:2015.

The safety of LNG maritime transport has been the most serious concern (Jiao et al., 2021). Given the fact that accidents are unavoidable, preventative measures are implemented to reduce their likelihood of occurring and minimize their impact. (Gucma & Mou, 2022). As a result, several recommendations and best practices have been developed for the gas and shipping industries to establish operational standards (Cassar et al., 2021). As a result of proposals from the OCIMF, SIGTTO, and ISO several safety systems have been implemented on board LNG carriers, additionally to mandated safety systems (IChemE, 2007), including LNG shipping suggested competency standards for cargo operations developed by SIGGTO. Its third edition was published in 2021, reflecting technological advancements and incident-related lessons learned since the last version was released (SIGTTO, 2022),

The Oil Companies International Marine Forum (OCIMF) established a voluntary Marine Terminal Management and Self-Assessment (MTMSA), and Marine

Terminal Information System (MTIS), enabling terminals to assess of the efficiency of the ship-port interface and operations management system, However, the ignorance and non-compliance of these procedures and standards by several LNG terminals have resulted in issues of safety of operations (Kuzu, 2015). As a result, the world's leading LNG producers and most trusted suppliers have established “due diligence procedures” to make sure that terminals are safe to call with a high level of confidence, which is essential for meeting their obligations to their extensive portfolio of buyers and optimizing their shipping capacity. Thus, terminals are evaluated to assure that they comply with national and international laws and are handled according to sound and safe practices, following the set of recommendations promulgated by recognized professional organizations and under the obligation to exercise due diligence to ensure that only safe terminals are agreed to trade on. Also, in order to harmonize procedure and practices for ship-to-shore interface and port operation, in 2010, the Technical Committee ISO/TC 67 adopted ISO 28460 related to Petroleum and natural gas industries - Installation and equipment for liquefied natural gas - Ship-to-shore interface and port operations (ISO, 2010), including the guidance ISO/TS 16901, issued in 2015 on performing risk assessment in the design of onshore LNG installations including the ship/shore interface.

Over the past years, OCIMF, ICS, and the International Association of Ports and Harbors (IAPH) have cooperated to develop and improve the International Safety Guide for Oil Tankers and Terminals (ISGOTT). ISGOTT appeared for the first time in 1978. Its sixth edition includes the most recent thoughts and ideas on various essential topics regarding Ship-Shore Safety, including bunkering operations checklists, has also been updated, incorporating new knowledge on the effects of human elements (OCIMF, 2021). The IMO secretary-general Mr Kitack Lim highlighted the importance of ISGOTT when introducing its sixth edition. He said:

> “*Global maritime regulations, enforced by flag states, are vital for ensuring that all ships, regardless of flag, can operate safely and efficiently wherever in the world they are trading. However, further detailed guidance on best operational practice is leveraged from the vast experience of industry professionals. Industry publications such as ISGOTT are therefore crucial for ensuring that the aims and objectives of IMO instruments, such as the MARPOL and SOLAS Conventions, are achieved in real life*.” (ISGOTT, 2020).

This research highlighted the absence of harmonised regulatory framework in terms of safety management for the ship-port interface in contrast to LNG carriers that apply, under the convention of Safety of Life at Sea (SOLAS) Chapter IX, the ISM Code as an obligatory code for the safe management and operation of ships and pollution prevention. This has reduced accidents and other threats during operations in the maritime industry. The ISM Code offers a worldwide regulatory framework for encouraging a comprehensive and combined safety management system in the maritime sector (Batalden & Sydnes, 2014), by eliminating inadequate management systems of shipping companies and poorly skilled crews, which cause severe events (Herdzik, 2019). Furthermore, in terms of security, the International Ship and Port Facility Security Code is one of the most critical pieces of compulsory regulation developed by IMO for ships and ports (ISPS Code). It gives a harmonized framework for assessing ships' and ports' risk and security levels (IMO, 2002). All ports and terminals are required to apply the ISPS Code, even though it does not include special provisions for LNG operations (IMO, 2019).

Although the shipping industry adopted several international mandatory standards and instruments to strengthen the safety on board vessels, the ports and terminals may always constitute an exogenous threat to ships, specifically when it comes to highly flammable products. For example, negligence regarding dangerous cargo, such as explosives and chemicals in bulk, has enormous environmental effects on communities and marine ecosystems. The massive explosion at the port of Beirut had a significant impact on the global environment, caused by the improper warehousing and segregation of hazardous goods (Alamoush et al., 2021). More recently on 27 of June 2022, at the Jordanian port of Aqaba, when the cable hoisting a tank carrying 25 tonnes of liquefied gas with a very high chlorine concentration snapped, the container fell, resulting in the deaths of at least thirteen people and the injuries of 300 others (Davis, 2022).

Further, OCIMF and SIGTTO have taken the next step; they have come up with recommendations that sound more like regulations and have left it to the commercial side to put pressure on operators. Here, the big oil and gas players are in a position to be game changers. A clear case and example is the mooring incident of LNG carrier Zarga on 2 March 2015 at South Hook Terminal (MAIB, 2017), which was managed and operated by ExxonMobil (the first largest oil and gas company in the world). The Zarga LNG/C was managed and operated by Shell (the second largest oil and gas company in the world), and where the cargo seller was Qatargas (the largest LNG exporter at the time and in which both ExxonMobil and Shell hold shares). The magnitude of the investigation launched after the incident had worldwide repercussions. Therefore, developing on global scale a harmonized mandatory regulatory framework regarding the safety management on the ship-port interface is more than necessary to enhance the safety of operations in LNG ports and marine terminals, permitting all vessels visiting terminals to use the same safety tool and procedures.

2.6 Risk Management in LNG Ports and Marine Terminals

The notion of risk has numerous definitions (Aven, 2012). It has often been connected with the possibility of losing something. Risk differs according to the consequences of these occurrences; the more serious the effects, the greater the risk. A "hazard" is a potentially harmful physical circumstance or condition (Trbojevic & Carr, 2000). According to ISO 31000, 2018), risk is defined as the “effect of uncertainty on objectives”. However, Aven and Heide (2009) describe it as "uncertainty and severity of an activity's repercussions".

Risk assessment is an integral component of risk management and an essential ingredient of an efficient safety management system (Kadir et al., 2017; Parviainen et al., 2021). There are multiple tools to assess risk. Established by the International Maritime Organization (IMO), Formal safety assessment (FSA) is one method for ensuring that action is made prior to the occurrence of a catastrophe. This procedure analyse the hazards associated with shipping operations and assessing the costs and profits of IMO's alternatives to prevent these hazards (IMO, 2019). Other tools for environmental risk assessment exist, such as the **IRGC** risk governance framework (Florin & Bürkler, 2017), and the European Food Safety Authority’s (EFSA) for food and feeding safety assessments (Aguilera et al., 2018). Therefore, port risk assessment is required due to its high-risk nature (İnan et al., 2017)

The ISO 31000 standard, for instance, includes risk management concepts and general rules that apply to ports or any public or private corporation, organisation and association (ISO, 2018). The standard includes risk management principles, framework, and process. The framework explains how to incorporate risk management into an organization's context. It is an iterative process comprising of the subsequent steps:

1. defining the scope, context, criteria;
2. risk assessment (including risk identification, risk analysis, and risk treatment);
3. recording and reporting;
4. monitoring and review, and
5. communication and consultation (ISO, 2018).

The risk management principles relate to the fundamental values and concerns recognized as best practices in risk management, such as structured, comprehensive, inclusive, dynamic, iterative, and based on the best existing data (ISO, 2018). Therefore, risk management requires factual, timely, relevant, accurate, and accessible information.

Considerations on maritime safety have gained significant interest in recent years. In addition, they continue to be subjects of relevance to the maritime sector and the primary concerns of all shipping stakeholders (Schröder-Hinrichs et al., 2013). Accordingly, several studies highlight the significance of implementing planned actions for development of safety management systems in the maritime.

According to Bubbico and Salzano (2009), the maritime sector has paid close attention to LNG's safety concerns. This includes the ports and terminals, which are vital to a nation's economy, and where significant operations and activities are carried out, including dangerous cargoes handling and storage, such as LNG (Ronza et al., 2009). Various papers on risk assessment pertaining to LNG carriage, handling and safe storage exist. Based on the literature study, the number of these papers has increased consistently over the past decade (Animah & Shafiee, 2020; Aneziris et al., 2020b), some of them Aneziris et al. (2014) provided comprehensive risk assessment framework of LNG terminals; (Vanem et al., 2008) discussed a high-level risk assessment of LNG carriers operations; (Budiarta et al., 2020) conferred quantitative risk assessment of LNG terminal; (J. Li & Huang, 2012) examined the risk assessment of fire and explosion for LNG ships. However, very few researchers, such as (Bybee, 2011) and (Elsayed et al., 2009) considered the risk analysis in regard to the ship-port interface during port operations.

Port operations are complex and dynamic, resulting in a wide range of hazards. If these risks are not properly handled, they may have a negative impact on the ports' and terminal' entire commercial activities (Kadir et al., 2017b). Given the complexity of operations, ports and terminals have been recognized as a place of risk, an area whereby risks may jeopardize people, the environment, and property (Bouzaher et al., 2015). Preventing accidents is crucial in the port sector and very critical and fundamental in an organisation's safety management system (Kadir et al., 2017, 2020). Therefore, the management and assessment of risks in LNG port and marine terminal operations are vital for sustaining the industry's safety record and reputation (Elsayed, 2010b)

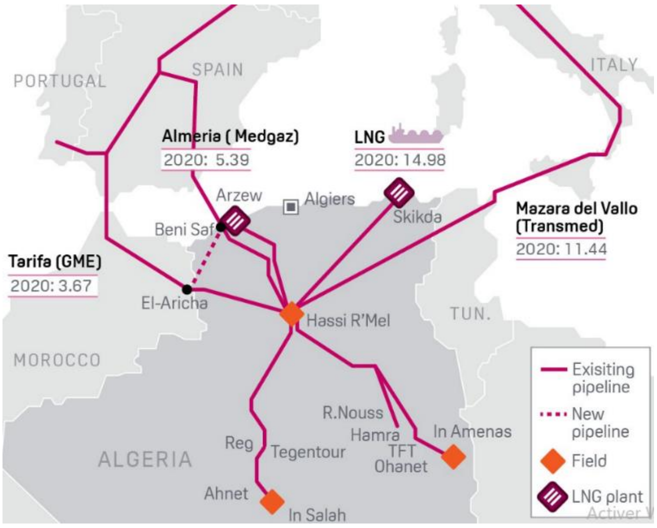
Risk management is essential for maintaining the safety of port and terminal operations (Pileggi et al., 2020). Different threats might generate many hazard sources in ports and terminals, which may significantly affect seaborne trade (John et al., 2016; Nagi et al., 2021)), particularly for the LNG sector. As a result, risk management should be incorporated into the fundamental operations and organisational culture (Hopkin, 2018a). While the relevance of risk management is increasing and getting more consideration in ports and terminals, there are no broadly applicable standards yet due to the fact that risk management operations are quite port-and stakeholder-specific (Nagi et al., 2017).

Although standardization and technological solutions have increased, significant accidents are still happening due to SMS failures. Increasingly, the fundamental reasons of failure are attributed to the safety management methods that are intended to maintain them. The primary goals of a successful SMS must be to ensure that: a) risks are identified and assessed; b) risks controlled appropriately for mitigation; c) management is accountable for ensuring controls are always effective. An effective SMS should be tailored to the technological system, including the incurred risks (Trbojevic & Carr, 2000).

2.7 LNG Ports and Marine Terminals in Algeria

Since the 1964 inauguration of Algeria's LNG terminal in Arzew, the first worldwide, the LNG sector has been a strategic instrument for Algeria, enabling improved gas development and export options. Algeria was the first nation to export liquefied natural gas (LNG) to the United Kingdom and Spain, In 1964 and 1969, respectively. Later, other gas export pipelines to the European continent were developed through Tunisia and Morocco (Andersen & Sitter, 2019). Figure 7 below shows the natural gas transportation network, including LNG marine terminals in Algeria.

Figure 7 *Algeria's Gas Transportation and Terminals Network*



Note. S&P Global Platts Analytics

Algeria is a leading supplier of natural gas in the African continent and is a former part of the Organization of the Petroleum Exporting Countries (OPEC) since 1969. The oil and gas industry contributes to approximately 50% of the country's GDP and, thus, more than 95% of exportation (Entelis, 1999). Algeria's exports of natural gas have steadily reduced over the previous decade due to a reduction in overall production and increased domestic consumption. However, this trend was reversed in 2016. Algeria increases its production through new projects in order to satisfy the rising demand for natural gas in the world and fulfil its contractual commitments to sell natural gas to Europe over the long term. In 2020, Algeria exported 26 billion m^3 of natural gas via export pipelines and 18 billion m^3 through the LNG port of Arzew (Bethioua) and Skikda (Sonatrach, 2020).

Algeria's National Oil Company, Sonatrach, holds almost 80 % of the country's hydrocarbon productivity and regulates the entire hydrocarbon industry (Andersen & Sitter, 2019). This includes natural gas liquefaction throughout four LNG terminals situated along the Mediterranean Sea, precisely in Skikda and Arzew ports (EIA, 2019), with an annual output capacity of 56 million cubic metres (Sonatrach, 2020). Table 2 indicates the existing gas liquefaction terminals in Algeria with the year of start-up.

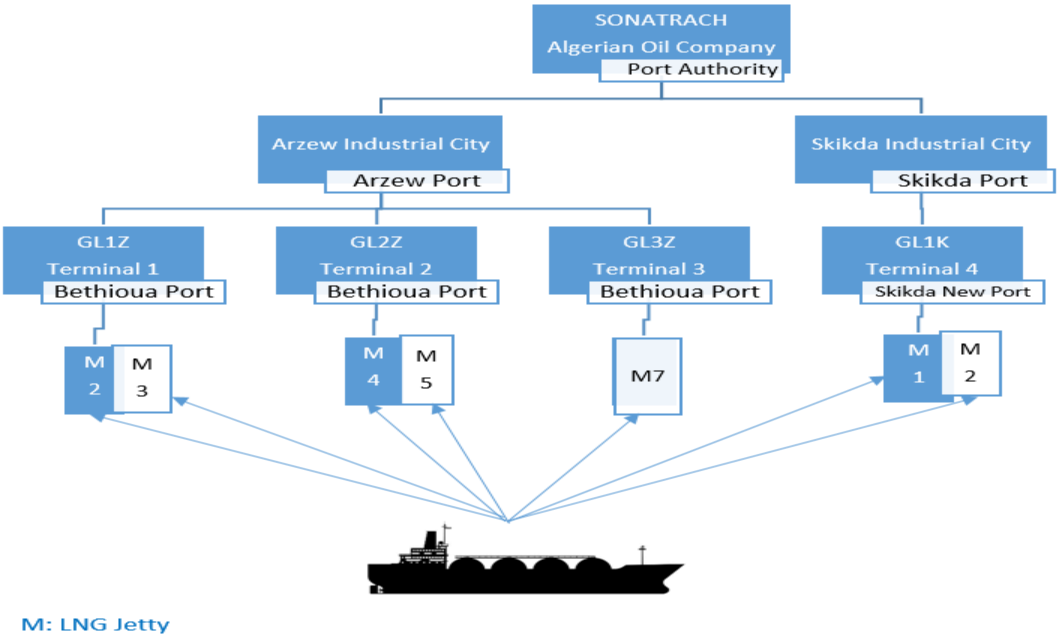
Table 2 *Existing LNG Terminals in Algeria*

Terminals	Name	Begin (Start-up)	Capacity (Million m^3)
Arzew	GL4Z (Arzew)	1964	disabled
	GL1Z (Bethioua)	1977	17.56
	GL2Z (Bethioua)	1981	17.82
	GL3Z (Bethioua)	2014	10.5
Skikda	GL1K (Skikda)	2013 (Fully restored after the 2004 explosion)	10

Note. (Sonatrach, 2020)

As indicated in figure 7, Algeria´s major LNG marine terminals are established in the port area, namely the LNG ports of Arzew and Skikda, where natural gas is liquefied at – 161 °C and loaded on board LNG carriers (Hu et al., 2021). Through its affiliate company, known under Hyproc Shipping Co., Sonatrach operates the Algerian LNG fleet, including other LNG ships co-owned with other entities. Figure 9 shows the Marine terminal distribution per LNG ports

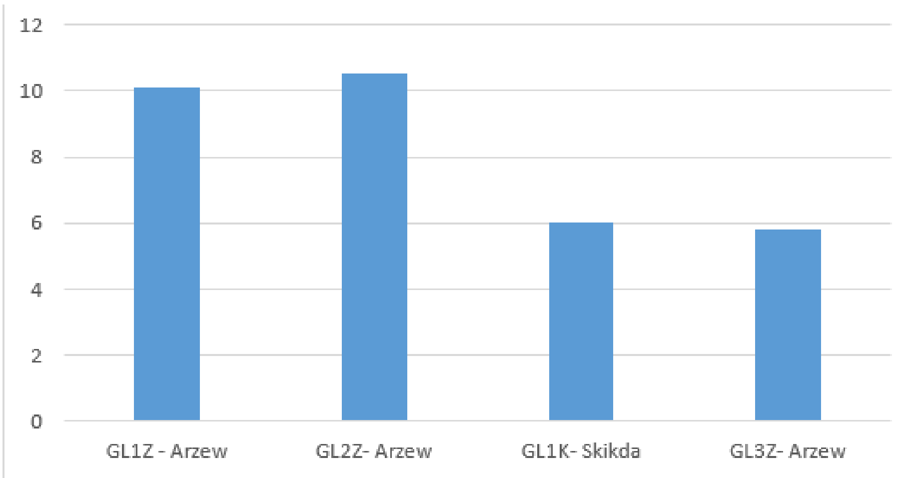
Figure 8 *Algeria's LNG export terminals*



Note. Developed by Researcher

According to Statista (2022a), Algeria's GL1Z and GL2Z LNG terminals recorded the largest production capacity in 2020 (see Figure 8). Both surpassing 10 million tonnes per year (MTPA). Each of these terminals is situated in the LNG port of Arzew (Bethioua).

Figure 9 *Capacity of Liquefaction Terminals in Algeria as of 2020 (MTPA)*



Note. (Statista, 2022a)

Algeria's LNG production increases as global demand grow. According to Statista, Algeria exported 16.1 billion cubic meters of LNG in 2021, compared to previous years (Statista, 2022b). Owing to these considerable demands, LNG port and marine terminals may be crowded, requiring thus heightened monitoring and vigilance throughout ship-port interaction, where a number of complex activities take place, including handling operations. Literature shows that over the past decades, at least eight serious LNG accidents occurred in Algerian LNG ports and marine terminals. The nature of accidents includes: weather conditions, overfilling, LNG leakage, grounding, equipment failure and loading arm breakage. The majority of accidents happened during LNG cargo operations. This fact reinforces the findings of studies conducted previously about LNG accidents. According to Vanem et al. (2008), the contributing factors to LNG shipping hazards include LNG events happening loading and unloading at terminals.

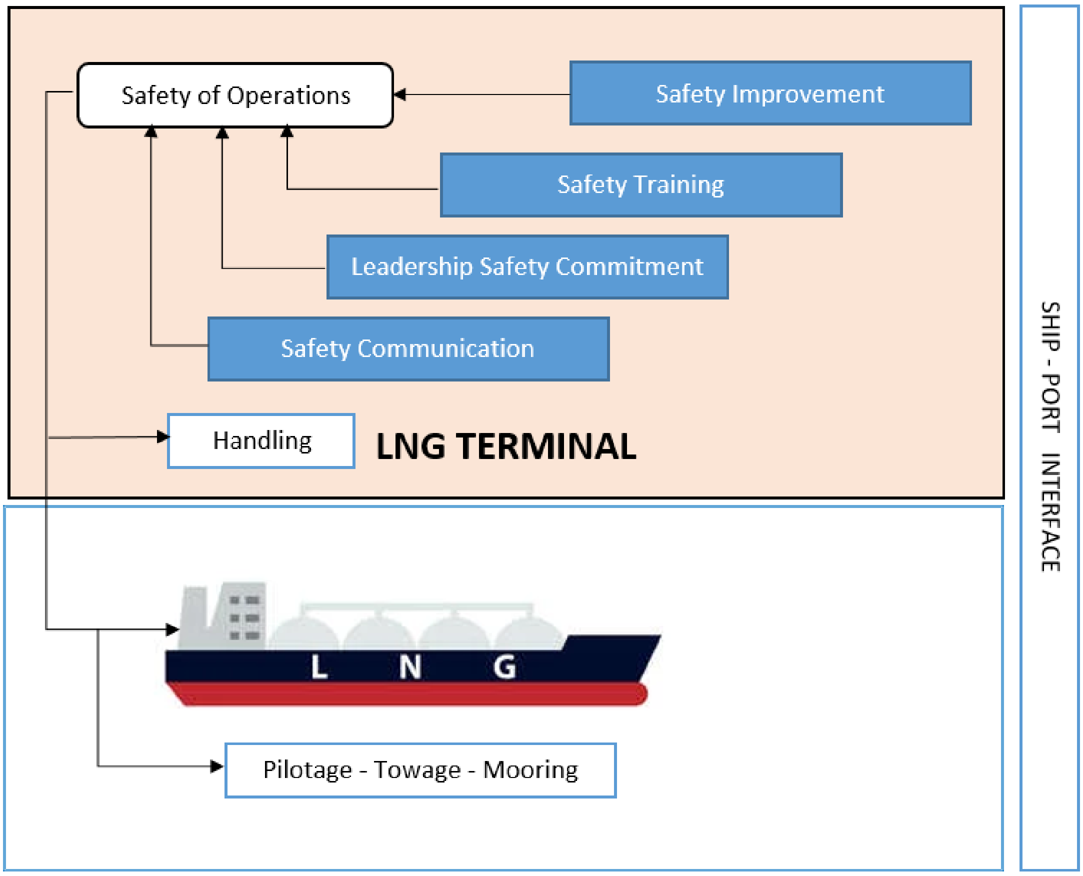
Furthermore, Darbra et al. (2005) argued that loading and unloading operations are the most critical elements contributing to port accidents. Consequently, measures based on an accurate investigation must be made to mitigate LNG terminal threats (Yun et al., 2009).

This study presents a comprehensive approach to the challenges of the ship-port safety management in LNG ports and maritime terminals in Algeria, with the aim of addressing gaps in the existing literature. The ship-port interfaces and related hazards in LNG Ports and marine terminals are a crucial yet unexplored study field, and which necessitates a detailed both academic and operational investigation. Therefore, as proactive the researcher will identify the contributing factors that may lead to accidents, specifically in the ship-port interface, and investigate the challenges in order to enhance safety in Algerian LNG ports and marine terminals.

2.8 Research Conceptual Framework

This conceptual framework used partially ISO 31000:2018 framework to identify the main factors that enhance safety in LNG ports and marine terminals. In other words, if these factors are not implemented; accident risks may considerably increase. In addition to ISO 31000:2018 framework other factors emerged from the literature review were integrated in the conceptual framework used in this study (see figure 11). The conceptual framework indicates that the safety operation at LNG terminals are influenced by serval factors.

Figure 10 Research Conceptual Framework



Note. Developed by Researcher.

Chapter 3: Research Methodology

3.1 Introduction

Choosing an adequate research methodology is an important step in conducting successful academic research. It must justify the methods adopted in the research (Helskog, 2014). The research methodology involves both the theoretical and philosophical basis of the study to ensure that the information generated is credible (Edum-Fotwel et al., 1996). This chapter discusses the approach used to address the research questions, and specifies the nature of empirical evidence and its attendees, the procedures followed, and the information analysis method selected (Rudestam & Newton, 2014). It will include research design, research strategy, methods for data gathering are covered, data analysis, research ethics, as well as the limitations associated to this research.

3.2 Research Design

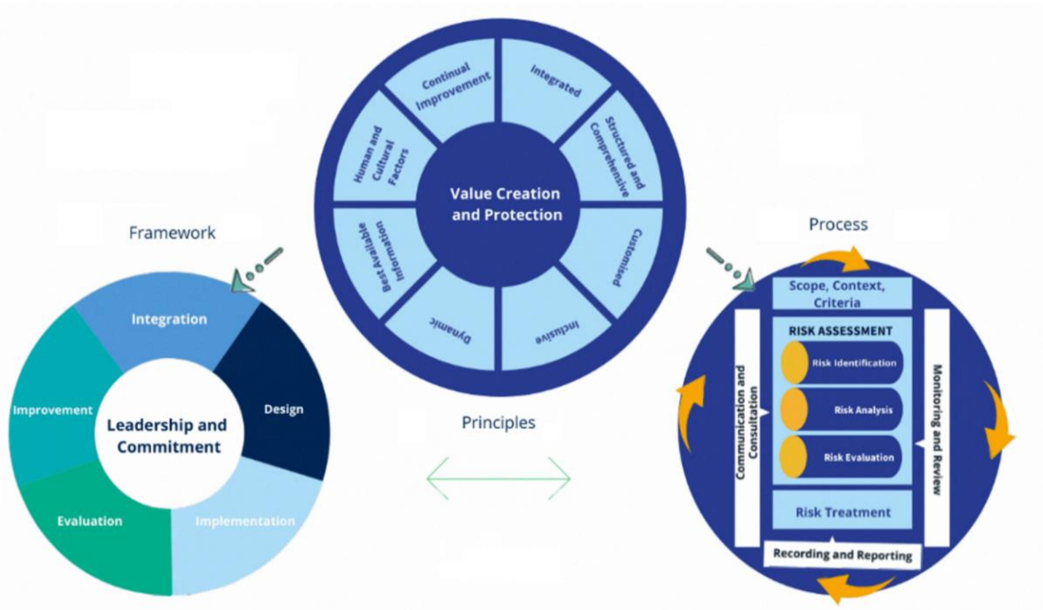
The research design can be defined as the fundamental research strategy and the primary purpose of conducting the study guarantee its validity and credibility (Marczyk et al., 2010). Choosing a suitable research methodology is a challenging process that requires a precise definition of the study purpose and objectives, including research questions and an understanding of the techniques of information gathering (Sutton et al., 2019). The logical relationship involving research questions, methodology, data gathering methods, and data analysis represents an evidentiary chain (Yin, 1994).

A thorough review was conducted to identify the gaps and develop research questions based on a complete comprehension of the literature. Very few studies have been identified about LNG ports and marine terminals in Algeria. Therefore, this research aimed to shed light on safety management in Algerian LNG ports and marine terminals. Specifically, it seeks to identify and evaluate the potential hazards and associated risks, using ISO 31000 standard as a framework. Accordingly, three research questions were outlined as follows:

1. What are the threats jeopardising safety in LNG ports and marine terminals with regard to the interface between ship-port?
2. What are the factors attributed to accidents/incidents in Algerian LNG terminals, particularly in the interaction between ship-port operations?
3. What are the challenges and the prospects to enhance the ship-port interface safety management in Algerian LNG ports and marine terminals?

To assist in addressing these research questions, the study explored the risk management guidelines of ISO 31000 as a theoretical framework (see Figure 10 below). According to Ravitch and Riggan (2016), theoretical frameworks are critical for developing research questions. They enable removing unnecessary data that may obstruct analysis and maintaining elements that may value from data comparison. Figure 8 presents the theoretical framework of the study.

Figure 11 *ISO 31000 Framework*

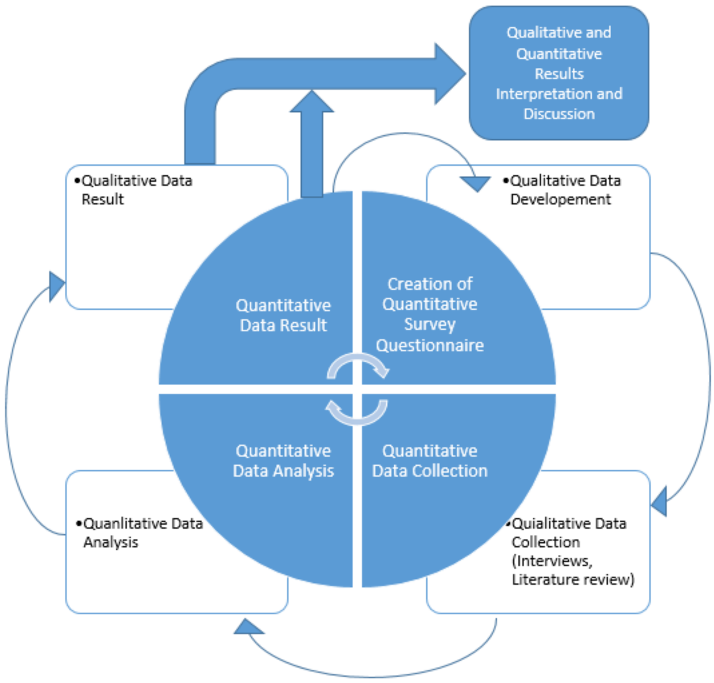


Note. ISO 31000: 2018 Risk management - Guidelines (ISO, 2018).

3.3 Research Strategy

In the present research, a mixed approach was applied. While the first step consisted of a quantitative approach using a questionnaire survey, the second step employed an exploratory qualitative method, using semi-structured interviews, data from accident reports, and literature reviews. This methodology enables both inductive and deductive thinking and the assessment of a wide range of data (Bryman, 2016). Näslund (2002) highlights the dependence only on quantitative research methods and recommends combining quantitative and qualitative approaches to bolster research strength. This method allows for a deeper understanding of facts (Ahmad et al., 2019). The researcher has established the framework in figure 9 to lead this research as a road map.

Figure 12 *Research Design*



Note. Developed by Researcher.

3.4 Data Collection

3.4.1 Qualitative Data Collection

The qualitative step is aimed at giving helpful information about the research subject and assists in developing the quantitative survey and, eventually, in the interpretation of the survey findings (Creswell & Creswell, 2017). There are several ways to collect qualitative data, including recording and transcribing interviews, semi-structured interviews with key staff in the organisation, communication with organization´s personnel, survey questionnaires, and literature studies. As a secondary source, the literature review was carried out first. According to Saunders et al. (2007), the literature review is beneficial and helps save time by using previously gathered data, which is also less costly than alternative techniques. However, the literature review data is expected to be combined with the other qualitative data acquired from experts. Second, the previous accidents that occurred in LNG ports and marine terminals, specifically, were collected and analysed. In addition to reviewing related literature and accident reports, semi-structured interviews were conducted to collect qualitative data. Saunders et al. (2009) emphasised the benefits of sampling. They recommended that by adopting a sample, the author may reduce the quantity of data collected and focus only on the targeted samples. Careful determining of the targeted population is a critical first step in a research study (Christensen et al., 2014). Thus, the main target is senior-level managers with safety management decision-making positions in LNG terminals. In this respect, a sample of qualified experts active in LNG port operations was selected, including harbour master, marine pilot, loading master, LNG ship captain, LNG terminal manager, tug master, and port facility security officer (PFSO), with a minimum of twenty (20) years' experience in LNG terminals (Figure 10 refers). The interviews were conducted with two experts from each one of the aforementioned functions. The participants were contacted first via email, and once they accepted the interview, a schedule was established containing the date and time for every participant. Some participants delayed their appointment following their absence away from the office for a business trip. The interviews were carried out mostly in the Arabic language, which is the mother language in Algeria. The selection of the interviewees is justified by the fact they are dealing with port threats on a daily basis and are aware of the dangers and risks inherent in their work. The questionnaire included open questions (see Annex 3) to allow participants to easily discuss and develop how safety management is performed in LNG terminals, including the associated hazards.

Figure 10 *Study Interview Composition*

Note: Developed by Researcher.

3.4.2 Quantitative Data Collection

Eldabi et al. (2002) highlight that quantitative research focuses on technique and statistical validity. It involves using statistical data to find correlations between sets of data. Thus, the present research relies on a quantitative survey questionnaire as a primary source in addition to the qualitative method.

As a result of the pilot study's results launched by research to harbour masters at a global scale seeking their ideas and views on issues and challenges in port safety, and based on ISO 31000:2018 standard, the researcher developed a detailed survey questionnaire related to research study questions.

Once the WMU Research Ethics Committee approved the questionnaire survey, the latter was translated into Arabic and French under the supervision of a certified translator. Google form was used as a tool, which is regarded as the most suitable and pertinent methodology to gather swiftly first-hand, in-depth, reliable, and high-quality data.

The poll was conducted among all employees and stakeholders involved directly with LNG ports and marine terminals in Algeria, specifically those of Arzew and Skikda. The survey objective was to obtain perceptions and professional opinions on safety management on LNG terminals, as well as the hazards and factors that affect the safety of operations.

Critical criteria were considered in developing the questionnaire survey as identified in the related literature. These include (i) the items in a questionnaire should be straightforward, unambiguous, and suitable for the participant's level of knowledge (Houtkoop-Steenstra, 2000); (ii) participants' characteristics, such as profession, education, and age, may reflect different schools of thinking (Bradburn et al., 1979); and (iii) the design of the questionnaire should be split into different parts, each part should target a specific aspect of the research goals (Frazer & Lawley, 2000).

About 48 questions were carefully drafted and corrected; the questions were structured in accordance with the conceptual framework, developed through risk management standards ISO 31000:2018 and the literature review. The survey was built in the form of Likert scale with 5 options (i.e., Strongly disagree- Disagree- Neutral- Agree- Strongly agree). The survey contained 7 sections including section dedicated to participant background information (see Annex 2).

The data collection started on 01 July 2022 and ended on 10 August 2022.

3.5 Data Analysis

The gathered data should always be analysed before being employed in later research steps. Yin (2009) states that the development of top-notch quality analysis involves using specific methodologies and techniques. In this research, thematic analysis was used to analyse qualitative data, and descriptive and statistical methods were used to analyse questionnaire survey data using the SPSS tool, i.e., correlation, regression, and factor analysis.

3.6 Research Ethics

According to Orb et al (2001), ethics are included in any research. The study method produces conflict between generalizing about others' interests and respecting participants' privacy. As a result, the questionnaire was designed to guarantee partial conditions to participants and in that the researcher followed World Maritime

University Ethics Committee requirements. Confidentiality and anonymity, research were all deemed ethical considerations, and all data obtained and used for this project will be erased upon dissertation submission.

3.7 Research Limitation

Despite the lifting of COVID 19 restrictions by certain countries, Algeria continuously applies preventive measures against the spread of this pandemic. As a result, the researcher could not personally travel to Algeria for data collection. Therefore, online interviews were used. Furthermore, the research is limited by time restrictions, which may somewhat impede the study's development.

Chapter 4: Data Analysis and Discussion

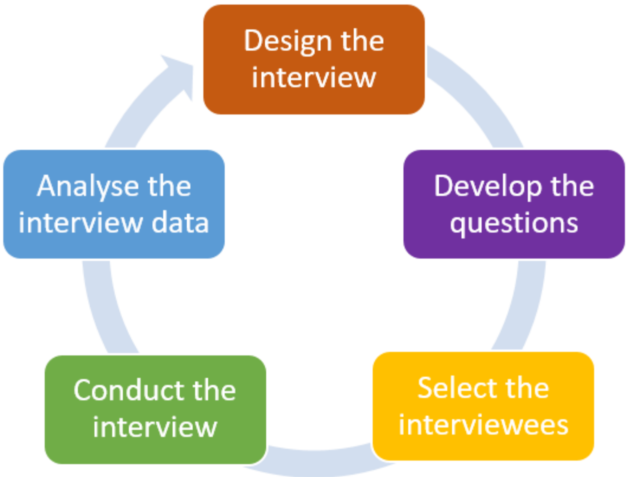
4.1 Introduction

This chapter explores, analyses and discuss the exploratory questionnaire survey results on ship-port interface safety management in LNG ports and marine terminals, and when deemed relevant to the study aims, it combines these conclusions with those gleaned from secondary sources. This chapter also includes the analysis of accidents involving LNG in the maritime sector since 1944, based on a literature review, as well as the qualitative and quantitative data analysis. The data analysis aims to answer the main research objective, which is to identify the frequent threats leading to accidents during port operations with regard to ship-port interaction and to boost our understanding of how safety management should work properly in reality. The data also gives explanations of LNG hazard categories, port professionals' and managers' responses and views on the efficacy of port safety management in LNG ports and marine terminals.

4.2 Qualitative Data Analysis

Qualitative semi-structured interviews are among the most prevalent and commonly applied techniques of data gathering (Bradford & Cullen, 2012). Four essential phases are common in qualitative data analysis methods, including data gathering, processing data, data presentation, and establishing and validating conclusions (Reich, 1994). Moreover, coding and categorizing data are approaches for organizing and preparing for the analysis (Schutt, 2018), and helps the researcher to develop interpretations (Zhang & Wildemuth, 2009). The fundamental objective of the qualitative survey was to investigate the safety management in LNG ports and marine terminals in Algeria, particularly with regard to interaction between the ship and port. Therefore, based on research study questions that were envisioned partially by ISO 31000:2018 framework, 22 interview questions were designed (appendix .. refer to interview questions). The interview's development and process are demonstrated in figure10 below.

Figure 13 *Interview Process*

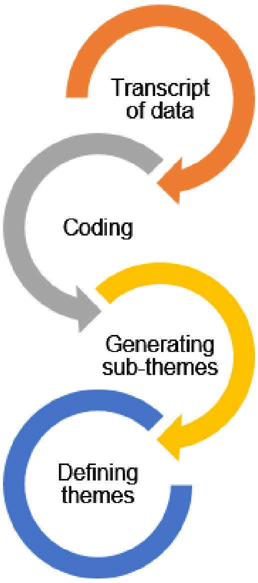


Note. Developed by Researcher.

4.2.1 Data Analysis of the Interviews

According to Richards and Morse (2012), qualitative data analysis process is a combination of transformation and interpretation. However, planning for the interviews, scheduling the interviews, conducting the interviews, and interpreting the interviews are not as straightforward as imaginable. Thorne (2000) defined data processing as the most difficult part of qualitative method. The effort and time needed to carry out everything correctly are significant. Semi-structured interviews often require rigorous examination of a vast quantity of notes, and frequently, long transcripts (Adams, 2015). The figure 11 below, illustrate the way how the analysis of qualitative data was performed.

Figure 14 *Qualitative Data Analysis Process*



Note. Developed by Researcher.

Interviews focused primarily on experts and specialists involved with LNG ports and marine terminals. These were done in order to corroborate the survey results with professional comments and gather data from respondents with relevant knowledge and experience. As mentioned in Chapter 3 (see figure 10), the targeted responders were therefore selected with care, including two experts from each of the seven professions involved in the port sector, the shipping industry, and LNG terminals dealing directly with the ship-port interface. Table 2 shows the interviewees' positions and experience, as well as the dates of participation. All experts were interviewed for approximately an hour, adopting a semi-structured method, including open-ended and straightforward questions. The majority of interviews were conducted online and recorded. However, two participants could not be interviewed due to their last-minute withdrawal. Before commencing the interviews, all participants completed and signed consent forms.

Table 3 *List and Profile of Interviewees*

Participants	Positions	Age	Experience	Interview date
Participant 1	Harbour Master	46 – 55	20 + years	03.07.2022
Participant 2		36 – 45	20 + years	20.08.2022
Participant 3	LNG Terminal Manager	36 – 45	20 + years	30.06.2022
Participant 4		46 – 55	16 – 20 years	07.07.2022
Participant 5	LNG/C Master	56 +	20 + years	04.07.2022
Participant 6		46 – 55	11 – 15 years	17.07.2022
Participant 7	Marine Pilot	36 – 45	20 + years	05.07.2022
Participant 8		46 – 55	11 – 15 years	13.07.2022
Participant 9	Tug Master	56 +	20 + years	16.07.2022
Participant 10		/	/	Not Conducted
Participant 11	Loading Master	26 – 35	11 – 15 years	29.07.2022
Participant 12		26 – 35	11 – 15 years	05.07.2022
Participant 13	PFSO	46 – 55	16 – 20 years	02.07.2022
Participant 14		/	/	Not Conducted

4.2.2 Interview Results

As illustrated in figure 11, data transcription was the ***first step*** of qualitative data analysis. According to Cope (2017), transcribing is used in qualitative research when researchers seek a written representation of their interactions with respondents or other audio materials for analysis. Data transcription require closes monitoring via repetitive and attentive listening (Bailey, 2008). Therefore, several readings and listening to the recordings interviews were performed to guarantee correctness. Moreover, before being analysed, the transcripts of the recorded interviews were reviewed for accuracy by the interviewees. The coding process was **the second step** following the transcription. Using thematic analysis method (reference), coding was carried out by underlining parts of text, words, and sentences, developing abbreviated designations or "codes" to explain their meaning, and then extracting sub-themes. According to Basit (2003), coding is an essential part of the analysis that aids organise and give meaning to text data. It entails fragmenting the data and creating categories (Dey, 1993). The table 3 shows a samples for the process of qualitative data coding.

Table 4 *Qualitative Data Coding*

Interview extracts	Codes
Participant 1 : "...we are restricted in terms of resources to ensure properly safety, we know that recruitment is limited but safety is also very important..."	Limitation of resources Workforce inadequate
Participant 2 : "...Safety is a more important than commercial activity since the repercussions of an event are so significant.	Safety is prioritized
Participant 11: "...There is overlapping of tasks and responsibilities, between services particularly in the ship-interface a designed person would be much better ..."	Task and responsibilities not defined
Participant 9: "...There are many conflicts between services, notably when it comes to stopping loading operations in case of a safety issue ..."	Lack of coordination
Participant 1: "...I have not received any training related to risk management since I joined my organization..."	Lack of Training
Participant 7: ".... the policy and the commitment of the top management are displayed everywhere. However, there is still a lot to do to enhance the safety in LNG terminals..."	Lack of commitment
Participant 9: "....In my opinion, to improve safety and mitigate risks in an LNG terminal, it is more than necessary right now to strengthen and multiply employees' awareness of hazards, as well as perform drills between all involved parties ..."	Safety awareness is required
Participant 6: "...meetings with involved parties before commencing LNG cargo transfer, to discuss safety measures is not carried out..."	Lack of meetings Information not shared
Participant 12: "... Except for the ship-shore safety check list, I did not acknowledge any other written procedures or instructions regarding safety in LNG terminal...."	Absence of safety procedures
Participant 6: "...safety measures are unknown, For instance, safety distance limitation during LNG operations is not determined and mooring boats engines are not certified spark proof ..."	Absence of safety procedures Safety inspections
Participant 5: "...Terminal was not able to ensure cargo operation transfer due to technical issues..."	Technical Problems

The ***third step*** focused on generating and developing sub-themes. The codes were assimilated into sub-themes that include elements of similar meaning derived from the answers of several participants. ***In the final step***, the ISO 31000 framework was used to develop the precise terminologies of themes and determine how they help in data comprehension. The following is a description of the themes and their linked sub-themes:

Theme 1: Leadership safety commitment

This theme was identified as a critical element to enhancing safety management in Algeria's LNG ports and marine terminals. This theme, thus, represent problems present in Algerian terminals. There are clear issues with the leadership and commitment with respect to safety operations in Algerian LNG terminals. The issues in the theme comprises the following sub-themes as have been previously coded and in line with the interviewees' response: a) allocation of resources, which include people and materials to perform operations in good condition. b) teamwork and a working environment, motivating employees to achieving the organization's goals. c) assignment of responsibilities, especially for those involved in safety at the ship-port interface, d) integration of risk management. This involves integrating risk management into the activities of the company and aligning it with its goals and strategies.

Theme 2: Safety of operations

Safety of operation of key element of safety management. It entails the implementation of policies and processes, as well as rules and requirements that apply to interactions between ships and LNG terminals. This theme includes three sub-themes highlighted during interviews. Theses includes: a) absence of safety management system (SMS), that may affect the organization of operations, this involves terminal information booklet, working procedures and practices, and emergency plans, b) lack of legislation for LNG operations, leading to overlapping of roles between port authorities, c) non-compliance with international standards issued by recognized organization in LNG port and marine terminal, such as OCIMF and SIGTTO.

Theme 3: Safety Training

According to interview participants, training is critical in enhancing safety in LNG ports and marine terminals. Regarding this theme, three essential sub-themes were identified. These involve a) lack of training for operational staff. Although a training program is established, the operational staff do not benefit significantly, particularly in terms of safety and risk management. For instance, the personnel assigned for mooring operations in LNG terminals are limited to STCW certificate training, excluding gas-related certificates. b) the absence of joint exercises and drills involving all stakeholders (ship, port, and terminal), which is very important to identify weaknesses and familiarizing employees for emergencies; c) communication training: this sub-theme involves the necessity of English language training for personnel engaged in LNG terminals and permanent contact with the ship.

Theme 4: Safety Communication

This theme encompasses three sub-themes: a) lack of information sharing, mainly information related to safety in LNG terminals. Several interviewees highlighted the absence of meetings before the loading operation. Also, it involves port and terminal information exchange regarding compatibility and berthing operations; b) the captain's feedback and comments. The interviews reveal a lack of consideration of safety measures and captains' perceptions of safety issues; c) communication issues between marine services while the ship is approaching the terminal jetty. It involves pilots, tugboats, and mooring services.

Theme 5: Safety Improvement

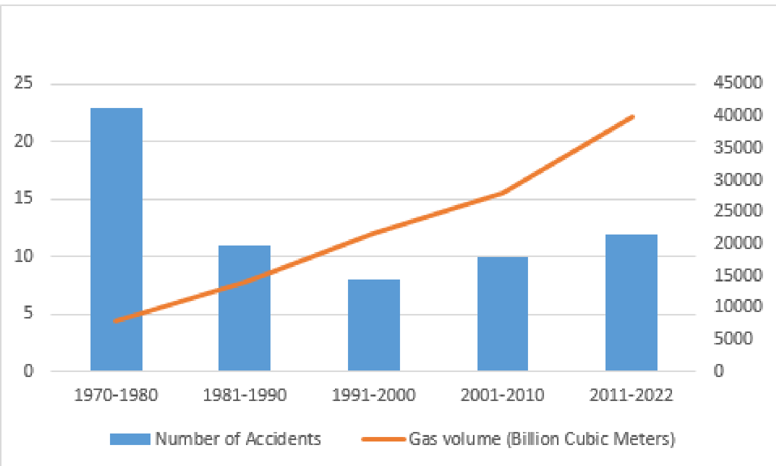
Participants emphasized the lack of continual improvement in LNG ports and marine terminals in Algeria. Four sub-themes were identified and coded through the interview analysis process, and these include: a) lack of non-conformity treatment, involving the recurrence of problems despite their reporting to the concerned parties. This may result in hazards for safety that can lead to accidents; (b) lack of maintenance, which involves deficiencies in equipment working condition, including mooring aids equipment fixed in the jetties and lack of lighting in the port area; (c) absence of risk assessment; (d) lack of audits in terms of safety management systems.

4.3 Quantitative Data Analysis

4.3.1 Accidents Analysis Based on a Literature Review

Accidents and incidents are never inevitable. Thus, experts require a thorough understanding of past occurrences in order to plan preventative measures (Gucma & Mou, 2022). Although the University of Texas in the United States demonstrated, in 2012, when publishing accident statistics, that LNG shipping has maintained an excellent safety record (Foss, 2012), Figure 14 related to the distribution of accidents by decades and gas production shows that there is progressive growth during the last ten years attaining (12) event, with a noticeable uptick from previous two decades (08) and (10) occurrences respectively. Numerous researchers who have investigated the accident frequency fluctuation as a result of time for chemical facilities, and carriage of dangerous goods, including the shipping industry, have concluded that the number of accidents has increased rapidly over the last decade (Darbra et al., 2005). This situation can be explained as a result of the rising demand for LNG last decade, due to the fact that several nations rely on significant shipments of LNG for energy and sea transport and handling of LNG are associated with many hazards and severe effects (Gucma & Mou, 2022). It is very important to highlight that during data collection and interviews, the researcher discovered that many accidents and incidents were not reported, particularly during the first phase of LNG long-term supply contracts and prior to the LNG spot market.

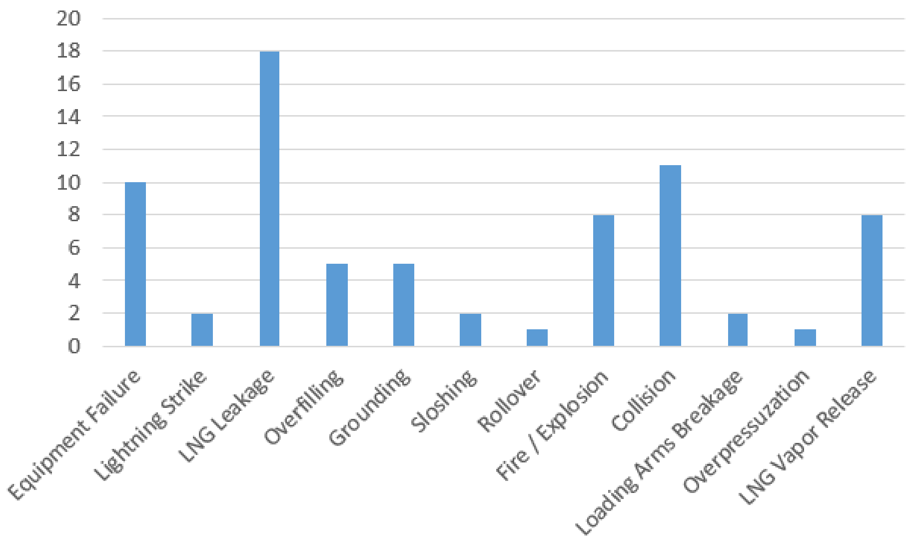
Figure 15 *Distribution of Accidents by Decades and Gas Production*



Note. (Riley & Riley, 2004); (Neves et al., 2008); (Liu et al., 2019); (Wood, n.d.)

The incidents are categorized into many types (LNG leakage, fire, explosion, equipment failure, grounding, LNG vapour release…etc.). Also, certain accidents may fall under more than one of these categories. For instance, fire might entail explosion and vice versa or even LNG leakage or LNG spill may generate fire and then explosion. As a result, the (fire, explosion) and (LNG spill and leakage) have been grouped into a single category.

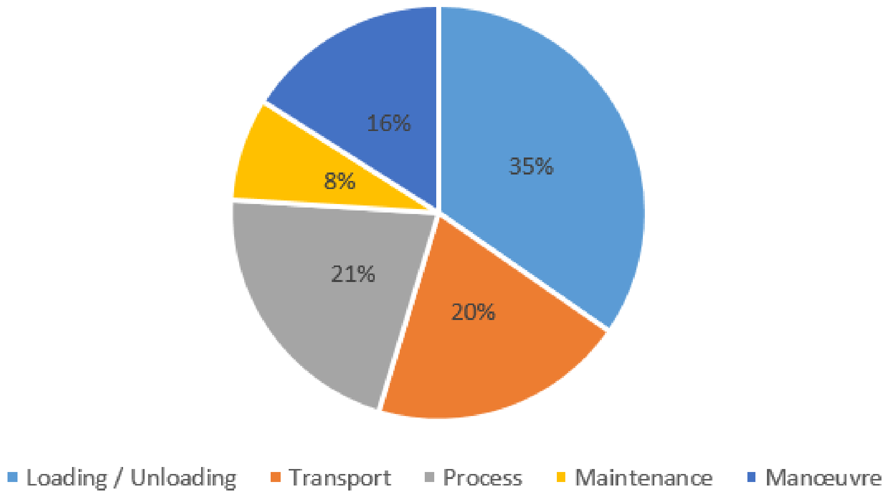
Figure 16 *Distribution by Nature of Accident*



Note. (Riley & Riley, 2004); (Neves et al., 2008); (Liu et al., 2019); (Wood, n.d.)

As can be seen in figure 13, 25% of accidents involved LNG leakage with (18) cases, 15% are related to collusion with (11) cases, 14% represent equipment failure cases with (10) events, and 08% are assigned for LNG vapour release, as well as, fire/explosion, with (8) occurrence for each one of them. Therefore, the most common accidents are LNG leakage, collision and equipment failure. However, as demonstrated in figure 14, the most significant phase where accidents happen is during loading and unloading operations, representing 35% of all accidents, followed by the phases concerning the process and transport of LNG with 16 and 15%, respectively. Also, it is interesting to highlight that these accidents occur in LNG ports and marine terminals during cargo operation, which means the ship-port interface is considered the most hazardous area where accidents occur most frequently.

Figure 17 *Distribution of Accidents Based on Type of Operations*



Note. (Riley & Riley, 2004); (Neves et al., 2008); (Liu et al., 2019); (Wood, n.d.)

4.3.2 Survey Analysis

4.3.2.1 Demographic Data of Participants

In order to attain a large number of participants, Skikda port authority was used as a hotspot to distribute the survey questionnaire to potential participants working in Algerian LNG ports and marine terminals, which includes Skikda and Arzew LNG port and those belonging to Algerian oil company, Sonatrach. Also, several participants were contacted directly through e-mail. WhatsApp was further used to circulate the survey on a large scale.

Table 5 *Gender and Age of Participants*

Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	80	97.6	97.6	97.6
	Female	2	2.4	2.4	100.0
	Total	82	100.0	100.0	

Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	26-35	22	26.8	26.8	26.8
	36-45	30	36.6	36.6	63.4
	46-55	15	18.3	18.3	81.7
	56+	15	18.3	18.3	100.0
	Total	82	100.0	100.0	

The demographic analysis of participants was performed by SPSS. The relevant information of all the participants are provided in this chapter. Among 250 professionals from LNG ports and marine terminals invited to participate in this survey, 82 responses were returned fully completed. We identified only two women, which represents 2,4 % of the total participation. However, the 80 male gender responders dominated with 97.6%. As can be seen in the table 3, the participants age range of 26-35 and 36-45 were predominant representing 26,8 and 36,6 % respectively, with a total of 52 participants.

Table 6 *Participants Organisations and Services*

Organization

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	SONATRACH - Arzew	14	17.1	17.1	17.1
	SONATRACH - Skikda	12	14.6	14.6	81.7
	Port of Arzew	25	30.5	30.5	67.1
	Port of Skikda	15	18.3	18.3	100.0
	Shipping Company	16	19.5	19.5	36.6
	Total	82	100.0	100.0	

Services

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Port Authority	22	26.8	26.8	52.4
	Pilotage	5	6.1	6.1	67.1
	Towage	10	12.2	12.2	100.0
	HSE	7	8.5	8.5	61.0
	Production	17	20.7	20.7	87.8
	Other	21	25.6	25.6	25.6
	Total	82	100.0	100.0	

Table 4 shows that the number of responders from the LNG ports in Algeria, namely Arzew and Skikda, was 40 participants, representing 30.5 and 18.3 %, respectively. These include the positions of deputy general manager (1), harbour master (3), deputy harbour master (1), port officer (17), PFSO (1), and deputy PFSO (1). The responders from LNG terminals operated by Algerian Oil Company (Sonatrach) counted 26 participants, distributed 17.1% for the Arzew terminal and 14.6% for the Skikda terminal, including terminal managers (3), loading masters (17), safety managers (2), and HSE supervisors (5). The shipping companies that are critical stakeholders for the LNG terminal also participated in this survey with a total of 16 participants, representing 19.5%. As indicated in the table 5, all of them were seafarers, holding the positions of masters (12), chief mates (6), chief engineers (2), deck officers (5), and gas engineers (2).

Table 7 *Participants Positions*

Position

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Chief engineer	2	2.4	2.4	2.4
	Chief Mate	6	7.3	7.3	9.8
	Deck Officer	5	6.1	6.1	15.9
	Deputy General Manager	1	1.2	1.2	17.1
	Deputy Harbour Master	2	2.4	2.4	19.5
	Deputy PFSO	1	1.2	1.2	20.7
	Gas Engineer	2	2.4	2.4	23.2
	Harbour Master	3	3.7	3.7	26.8
	Supervisor HSE	5	6.1	6.1	32.9
	Loading Master	17	20.7	20.7	53.7
	Marine Pilot	5	6.1	6.1	59.8
	Master	12	14.6	14.6	74.4
	PFSO	1	1.2	1.2	75.6
	Port Officer	15	18.3	18.3	93.9
	Safety Manager	2	2.4	2.4	96.3
	Terminal Manager	3	3.7	3.7	100.0
	Total	82	100.0	100.0	

In terms of experience, as demonstrated in Table 6, only six (6) people have less than five years' experience. However, most responders have more than five years of experience in LNG ports and marine terminals of which 37.8% of them have more than 20 years of experience, with 22% in LNG port and marine terminals. Consequently, the findings demonstrate that the majority of respondents have a wide range of experience with LNG port and marine terminals.

Table 8 *Participants Experience*

Experience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	>5 years	12	14.6	14.6	14.6
	5-10 years	18	22.0	22.0	36.6
	11-15 years	15	18.3	18.3	54.9
	16-20 years	6	7.3	7.3	62.2
	20+ years	31	37.8	37.8	100.0
	Total	82	100.0	100.0	

Experience in LNG Terminal

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	>5 years	6	7.3	7.3	7.3
	5-10 years	15	18.3	18.3	25.6
	11-15 years	25	30.5	30.5	56.1
	16-20 years	18	22.0	22.0	78.0
	20+ years	18	22.0	22.0	100.0
	Total	82	100.0	100.0	

Based on the demographic data presented above; it can be assumed that a broad variety of respondents have been captured in this questionnaire. Put differently, the analysis represents those who can give credible answers on the subject under investigation.

4.3.2.2 Factor Analysis and Cronbach Alpha (Reliability)

Reliability is "involved with the consistency of survey and, particularly, whether or not it can provide similar results across distinct periods and situations." (Saunders et al., 2009). In this section we distributed the questions into different factors by using SPSS. The Kaiser-Meyer Olkin (KMO) and Bartlett’s tests is performed to check whether the data is suitable for factor analysis or not. If the KMO test value is below 0.50, the factor analysis findings will likely not be very relevant (Verma & Ahmad, 2016). The P Value (Significance) of the Bartlett test must be less than 0.05 to conclude that the data is statistically significant and the factor analysis result is acceptable (N. Li et al., 2020). As shown in table 7, the test value of KMO and P value were 0.822 and 0.000, respectively, which mean that the results are quite acceptable.

Table 9 *KMO and Bartlett's Test*

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.822
Bartlett's Test of Sphericity	Approx. Chi-Square	3301.398
	df	666
	Sig.	.000

After validating the KMO test results, factor analysis was performed using SPSS. Table 9 illustrates the five factors created. These factors contain the questions (measure items), and the measure items' Cronbach alpha, which is observed to be significant for all the factors, i.e., it is above 0.70. For the data to be deemed reliable, as recommended, Cronbach's alpha must be greater than or equal to 0.70 (Bujang et al., 2018). Eigen Value of the components should be greater than 1 (Wallbrecher et al., 1996). In our study, they were all higher than one, indicating that the variables are highly explanatory of the data and statistically significant.

Table 10 *Factor Analysis and Reliability Test (Cronbach Alpha)*

Factors	Cronbach Alpha	Eigen Value	Item	Factor Loading
Factor 1: Safety of Operations	.928	15.165	Q 12. The operator ensures the safety operations of the ship-port interface	.828
			Q 10. The Safety procedures can be easily comprehended	.716
			Q 17. The risk assessment is carried out before performing duties	.699
			Q34 Q 34. The safety internal audits and inspections are carried out regularly	.686
			Q 24. The mooring pattern are regularly monitored during handling operation.	.677
			Q 11. The port authority ensures the safety operations of the ship-port interface	.647
			Q 23. The mooring equipment fixed in the terminal and the berthing structures are regularly maintained and inspected	.639
			Q 21. The employees conform to the required protective equipment	.616
			Q 9. The Safety procedures are readily available	.505
Factor 2: Safety Communication	.879	4.035	Q31. Safety measures are discussed, communicated and shared effectively with our stakeholders.	.886
			Q 32. The emergency response plans are clearly displayed and communicated to those concerned.	.867
			Q 33. Safety meetings are frequently carried out with different services to discuss and share safety measures.	.715
			Q 30. We are informed about accidents or incidents that occurred in other ports/ LNG terminals.	.619
			Q 29. The lessons learned from incidents and accidents, are shared with all the involved parts in port / LNG terminal	.552
			Q 15. The accidents, incidents and near misses are reported verbally to the top and/or middle management.	.511
Factor 3: Leader Safety Commitment	.849	2.952	Q 1. The top management displays a strong commitment to enhancing safety	.663
			Q 2. The top Management prioritizes safety over commercial activities.	.661
			Q 4. The necessary resources are allocated to managing safety.	.646
			Q 8. The authorities, responsibilities and accountabilities are assigned to the appropriate and relevant persons at different operation/administration levels.	.645
			Q 5. When safety concerns are brought to the attention of the top management, we receive positive feedback.	.592
			Q 3. The top management ensures that risk management is integrated into all relevant operations	.563
Factor 4: Safety Training	.880	1.840	Q 26. Risk management training is conducted periodically and continuously	.800
			Q 25. Safety management training is conducted periodically and continuously	.791
			Q 18. The employees' risk awareness level is very high	.691
			Q28. The staff training is sufficient to handle critical and hazardous situations.	.637
			Q 27. Exercises (drills) and simulations are carried out regularly in our port/ LNG terminal	.598
Factor 5: Safety Improvement	.703	1.664	Q 7. There is a reward policy initiative for the employee to improve safety.	.818
			Q 37. The non-conformities and observations noted through audits and inspections are treated and tracked until their close-out	.641
			Q 36. There is a continuous improvement in safety in our port/ LNG terminal	.527

Factor analysis identifies the number of factors within a collection of variables and their loading values. However, each question loaded into the factors should have more than 0.50 factor loading, and variables representing a factor are maintained while those representing several factors or none are deleted (Hair et al., 2006; Tabachnick & Fidell, 2007). Also, understanding factor loadings for decisions raises many challenges. First, it is unknown when a variable adequately loads onto a factor to be called representative. Second, it is unclear whether a variable reflects a sufficient number of factors. Thankfully, researchers give many cut-offs (Howard, 2016). According to Hinkin (1998), the most commonly used cut-off for "adequate" factor loadings on a significant factor is 0.40. Concerning the results, all factor loadings exceeded the value of 0.50, indicating that all of the factors were fulfilled. It is worth noting that some questions did not load into any factor, therefore, they were excluded. These include Questions 6, 13, 14, 16, 19, 20, 22 and 35. Table 8 below explains the reasons for excluding these questions.

Table 11 *Questions Excluding Explanation*

Question	Excluding reasons
Q6	It is deleted because the factor loading is negative (-.612).
Q13	The factor loading is included in both the 3rd (.593) and 4th (.573) variables.
Q13	It is deleted because the factor loading is negative (-.656).
Q16	Factor loading is included in both variable 2 (.552) and variable 5 (.503).
Q19	It is deleted because the factor loading is low.
Q20	It is deleted because the factor loading is low
Q22	It is deleted because the factor loading is low.
Q35	The factor loading is included in both variable 1 (.651) and variable 2 (.600).

The following are the definitions of the five divided factors:

Factor 1: Safety of Operations

This factor reflects the employee's perception of the safety policy, procedure, and practices with regard to the safety of operations in LNG ports and marine terminals. In addition, the factor encompasses how the hazards are treated, monitored, assessed, and reported, including risk management integration as a part of safety operations and decision-making.

Factor 2: Safety Communication

It is related to the perception of all concerned parties involved in LNG ports and marine terminals about how information on safety management and hazards are discussed and shared within the organization, including consideration of feedback contributing to decisions in terms of safety and how it matches the expectations of stakeholders.

Factor 3: Leadership Safety Commitment

It reflects the employee's perception of how top management shows leadership, commitment, and determination in terms of safety management in LNG port and marine terminals and how they focus on ensuring that risk management is incorporated into all organizational processes.

Factor 4: Safety Training

It refers to the level and frequency of training for employees working in LNG ports and marine terminals in terms of safety and risk management, including exercises and drills involving all concerned parties.

Factor 5: Safety Improvement

It is centred on workers' satisfaction concerning efficiency, effectiveness, and continuous safety improvement in LNG ports and marine terminals, as well as identifying and dealing with related gaps or opportunities for organizational improvement.

4.3.2.3 Regression Analysis

Regression analysis is among the most widely employed statistical research methods. In its most basic form, regression analysis enables researchers to examine the relationship between several independent factors and single dependent factor. Principal advantages of regression analysis are showing whether independent variables are related to a dependent variable, comparing the independent variables' effects on the dependent variable, and confirming hypotheses (Wagschal, 2016). In this study, the Safety of Operations (factor 1) is dependent factor, and the following factors: safety communication (factor 2), leadership safety commitment (factor 3), safety training (factor 4), safety improvement (factor 5) are considered as independent variables. Table 10 below demonstrates the regression findings. As can be seen, the dependent variable, Safety of Operations, is explained by 64,9 % of the model. In other words, the R2 and adjusted R2 are 0.649 and 0.611 respectively, representing thereby the goodness of fitness and also demonstrating the model robustness.

Regarding the value of Durbin-Watson test, it is 1.176 meaning it is acceptable which confirms the positive autocorrelation between relationships. This test is conducted according to autocorrelation regression model.

The Durbin-Watson test is intended to find autocorrelation problem among a linear regression model’s disturbance. One can thus anticipate that its strength is greatest when the issue is most significant, i.e., when the correlation between adjacent disturbances is near to one (Krämer, 1985). The value of Durbin-Watson can be between 0 – 4. However, a value over 2 indicates a negative autocorrelation and a value below 2 indicates positive autocorrelation (Norris et al., 2007).

Table 12 *Model Summary Results*

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.806[a]	.649	.631	.46847	1.176

a. Predictors: (Constant), Factor5, Factor2, Factor4, Factor3

b. Dependent Variable: Factor1

Table 11 indicates the dependent variable (safety of operations) and other independent variables previously mentioned. The significance is explained by the coefficients value, P (Sig) value, which holds a value between 0 – 1. If the P value is less than 0.05, the factor is significant and we should reject the null hypothesis (the null hypothesis states that the variable's coefficient is equal to zero) (Walsh et al., 2014). In other words, the rejection of the null hypothesis indicates the existence of relationships between components. According to results of table 11, as dependent factor, safety of operations is affected by all independent factors. This explained by the fact that their p value of is under 0.05.

Table 13 *Coefficients Results*

Coefficients[a]

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	VIF
1	(Constant)	.176	.245		.719	.001		
	Factor2	.350	.074	.370	4.710	.000	.741	1.350
	Factor3	.152	.099	.150	1.533	.000	.478	2.093
	Factor4	.353	.070	.406	5.058	.000	.707	1.415
	Factor5	.140	.098	.126	1.440	.001	.594	1.685

4.3.2.4 Correlation Analysis

Correlation tests are undoubtedly among the most frequently applied statistical methods and are the basis for a wide range of applications, such as including exploratory data analysis (Makowski et al., 2020). In correlation analysis, the direction of the relationship between variables is determined. In addition, Pearson correlation evaluates the availability shown by a P value and strength represented by a coefficient "r" ranging ± 1 of a linear connection between two variables. If the value of "r" is zero, there is no correlation between the variables. However, values between 0 and 1 indicate a positive correlation, whereas values between -1 and 0 indicate a negative correlation (Samuels, 2015). In a positive correlation, if one variable rises, the other will likewise increase, whereas in a negative correlation if variable reduces, the other variable decreases.

Regarding the P value, if the result is statistically significant, we deduce a relationship exists (Samuels, 2015). The Sig value needs to be less than 0.05 to confirm that the correlation is significant. Otherwise, if it is greater than 0.05, it indicates no correlation (GILITWALA & NAG, 2021). As evidenced by the results in table 12, the independent factors highly correlate with the dependent variable relevant to the safety of operations since they have a significant p value below 0.05. The variables representing leadership safety commitment and safety training factors were the uppermost, with r values of. 623 and.648, respectively.

The results also show a significant correlation between all the independent factors themselves. As indicated in table 12, safety communication directs a high correlation with safety leadership commitment (r=.506). Furthermore, the safety leadership commitment was highly correlated with safety training and safety improvement, with r values of .513 and .617, respectively. Regarding safety training, it was further correlated with safety improvement with an r value of .451.

Table 14 *Correlations Results*

Correlations

		Factor1	Factor2	Factor3	Factor4	Factor5
Factor1	Pearson Correlation	1	.609**	.623**	.648**	.532**
Safety of Operation	Sig. (2-tailed)		.000	.000	.000	.000
	N	82	82	82	82	82
Factor2	Pearson Correlation	.609**	1	.506**	.293**	.352**
Safety Communication	Sig. (2-tailed)	.000		.000	.000	.001
	N	82	82	82	82	82
Factor3	Pearson Correlation	.623**	.506**	1	.513**	.617**
Leadership Safety	Sig. (2-tailed)	.000	.000		.000	.000
Commitment	N	82	82	82	82	82
Factor4	Pearson Correlation	.648**	.293**	.513**	1	.451**
Safety Training	Sig. (2-tailed)	.000	.000	.000		.000
	N	82	82	82	82	82
Factor5	Pearson Correlation	.532**	.352**	.617**	.451**	1
Safety Improvement	Sig. (2-tailed)	.000	.001	.000	.000	
	N	82	82	82	82	82

**. Correlation is significant at the 0.01 level (2-tailed).

4.3.3 Frequency Analysis of Survey (the Algerian case)

Based on the questions of the surveys, the status in the Algerian ports with respect to the factors identified in the previous analysis are explained as follow. The result show problems and also discuss the probable root causes in line with the ISO.

4.3.3.1 Leadership Safety Commitment

In the following table 15, we can see frequency and percentage of responses on the questions (items) that compose the leadership and commitment.

Table 15 *Frequency Table of Leadership Safety Commitment*

Items	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Q1	31.7%	30.5%	17.1%	19.5%	1.2%
Q2	29.3%	35.4%	14.6%	17.%	3.7%
Q3	26.8%	34.1%	20.7%	17.1%	1.2%
Q4	13.4%	25.6%	42.7%	18.3%	00%
Q5	7.3%	31.7%	39.0%	22.0%	00%
Q6	15.9%	28.0%	8.5%	36.6%	11.0%
Q7	3.7%	8.5%	39.0%	22.0%	26.8%
Q8	6.1%	34.1%	23.2%	19.5%	17.1%
Mean	17%	28%	26%	22%	8%

As can be seen, only 45 % of respondents agree and strongly agree that the management in Algerian ports are committed to enhancing safety. On the contrary, 56 % disagree, including 26% of neutrals. This statement was confirmed during interviews, several issues related to leadership and commitment were highlighted. These may impact significantly safety in LNG ports and marine terminals. For instance, lack of allocating resources and integration of risk management at the different levels of organisation particularly during LNG cargo operation. Moreover, the correlation analysis demonstrated that leadership safety commitment was among the most significant correlated factors to the safety of operations in LNG ports and marine terminals with highest value of ".623". the findings illustrate that leadership and commitment has also high relationships with all variables, recording the highest values of correlation results not less than ".506". Therefore, the findings suggest that the top managers in Algerian LNG ports and marine terminals should reinforce their commitment toward safety of operations in the ship-port interface similar to other activities. According to (ISO 31000/2018) and based on research conceptual framework, this can be achieved through the implementation of risk management system within LNG ports and marine terminals by adopting a policy that set risk management strategy, assigning roles and responsibilities at that level, establishing a good working internal environment for employees, and considering stakeholder's feedback and perception. Leadership and commitment are not limited to policy display. Nevertheless, managers should demonstrate real commitment by allocating the required resources to enhance safety management in the ship-interface. A successful risk management implementation, leaders and managers must ensure commitment to the risk management process at all organizational levels (Lark, 2015) and guarantee that sufficient resources are dedicated to risk management (ISO 31000:2018).

4.3.3.2 Safety of Operations

Table 16 *Frequency Table of Safety of Operations*

Items	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Q9	14.6%	51.2%	13.4%	20.7%	00%
Q10	12.2%	35.4%	17.1%	35.4%	00%
Q11	8.5%	46.3%	31.7%	9.8%	3.7%
Q12	7.3%	59.8%	29.3%	3.7%	00%
Q13	12.2%	57.3%	19.5%	9.8%	1.2%
Q14	8.5%	34.1%	26.8%	25.6%	4.9%
Q15	17.1%	59.8%	11.0%	12.2%	00%
Q16	9.8%	42.7%	34.1%	11.0%	2.4%
Q17	8.5%	36.6%	41.5%	13.4%	00%
Q18	7.3%	52.4%	7.3%	31.7%	1.2%
Q19	6.1%	54.9%	18.3%	17.1%	3.7%
Q20	8.5%	50.0%	13.4%	25.6%	2.4%
Q21	9.8%	30.5%	28.0%	22.0%	9.8%
Q22	3.7%	11.0%	18.3%	34.1%	32.9%
Q23	12.2%	25.6%	20.7%	25.6%	15.9%
Q24	14.6%	45.1%	15.9%	20.7%	3.7%
Mean	10%	43%	22%	20%	5%

Safety of operations is a key factor within LNG ports and marine terminals. Evidence from literature review demonstrated that over the past decades, the LNG cargo operation phase was the most important part of accidents, representing 35% of the total, followed by those related to LNG process and its transport by sea, with 22 and 20 %, respectively. in the case of Algeria, the results imply that the safety of operations in LNG ports and marine terminals is lacking in effectiveness. 53 % of responders strongly agree and agree that safety of operations is efficient. In contrast, 25% strongly disagree and disagree. However, 22 % of responders escape to answer question and just choose to be neutral, which means that a lot of people are not able to decide, involving another issue of knowledge and competency. This element was confirmed through the interviews, stated, that lack of knowhow, ignorance and self-confidence are main drivers to accidents.

Even though 65.8% of responders from the Algerian LNG terminal sector believe that safety procedures are readily available, 35% consider that safety procedures are not easily comprehended, and 17.1% neither denied nor confirmed this, which denotes a procedural issue. This was confirmed by interviewees, holding a key operational positions, highlighting that the lack of a safety management system (SMS) and regulation that address the ship-port interface is the principal reason for the overlap in applying procedures and practices (port, ship, and terminal), as well as the assignment of roles and responsibilities of the involved parties. Interviews also reveal a lack of collaboration between services, notably during marine operations, resulting in entrance and departure delays for ships. Another, interviewee point out lack of delimitation of “safety moving zone” in Algerian LNG terminals pose serious concern. The restrictions of this zone should be determined by performing a risk assessment, taking into consideration some parameters, such as traffic flow, weather conditions, potential risks (ISO 28640,2010).

In terms of risk assessment, survey responses showed that risk assessment is not performed properly in Algerian LNG terminals, this includes the absence of tools in assessing hazards. When answering the question Q3, 60,9% of participants strongly agree and agree that risk assessment is integrated into all relevant activities. However, Q17 response reveals that the same participants did not confirmed that risk assessment is really carried out before duties, 41.5% neutral and 13,4% disagree.

ISO 31000:2018 states that risk assessment is an integrated part of the risk management system. Therefore, risk must be managed both throughout the organisation as a whole, or within particular areas, including strategy and decision, activities, procedures, roles, goods, services, and resources (ISO 31000:2018). Hence, leaders and manager of Algerian LNG ports and marine terminals should ensure that a systematic, continuous, cooperative risk assessment is conducted using the best existing data, including stakeholder's perspectives (ISO31000:2018).

Findings also revealed a problem of roles overlapping between involved parties in the ship-port interfaces. For instance, when answering Q11 and Q12, the same responders consider that both the port authority and the port operator ensure the ship-port safety management, which means that roles and responsibilities are not well-defined. This was confirmed by interview participants 11 and 12, emphasizing that the ship-port interface involves other different authorities in addition to port operators. Therefore, designating one responsible will be more to ensure the safety of operations.

Regarding relationships of safety of operation with other variables, correlation results showed the existence of very high correlation, recording the most important values, namely, safety communication ".609", leadership safety commitment ".623", safety training ".648", safety improvement ".532". therefore, the results deduced that safety of operation is critical and central element in regards to ship-port safety management in LNG ports and marine terminals.

In fact, safety in LNG terminals starts prior to the ship's arrival through rigorous planning of operations and implementation of all applicable regulations, standards, and procedures related to LNG cargo operations. However, findings showed that international standards issued by recognized organizations, such as OCIMF and SIGTTO are not applicable is Algerian LNG port and marine terminals. For example, ISO 28640:2010 recommends to examine all aspects before starting LNG handling operations. This includes berthing and unberthing operations to eliminate the possibility of any incident and guarantee the safety of the operation. It is also required to conduct a vetting investigation to confirm that the vessel's conditions are adequate for the loading operation.

According to CIMF (2004), LNG ports and marine terminals should implement a management system that can show compliance with legal instruments and standards, including terminal procedures and policy. The designation of "responsible" is to ensure that rules and procedures are applied. Moreover, terminals should confirm that ships transiting through their facilities apply appropriate international and national maritime legislation.

4.3.3.3 Safety Training

Table 17 *Frequency Table of Safety Training*

Items	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Q25	2.4 %	31.7%	23.2%	34.1%	8.5%
Q26	1.2%	34.1%	20.7%	35.4%	8.5%
Q27	8.5%	32.9%	25.6%	29.3%	3.7%
Q28	4.9%	15.9%	53.7%	18.3%	7.3%
Mean	4%	29%	31%	29%	7%

Regarding the safety training factor, as seen in table 17, there is a glaring lack of training in Algerian LNG ports and marine terminals. For instance, by answering the questions Q25, Q26, and Q27, 36% of responders confirmed that training in terms of safety and risk management are not performed correctly, and 33% believed the contrary. However, about 31% of participants remained neutral. As a result, findings imply that if neutral participants have followed safety training, including drills and exercises, nothing prevents them from responding favourably. The same table indicate that only 20.8% of responders believe that staff training is adequate to handle critical and dangerous situations. However, 25,6% disagree and strongly disagree, including 53.7% neutral.

The same statement was observed during the analysis of qualitative data. It was noticed that most interviewees had not received training for a long time, especially those engaged in operational activities. For example, seafarers assigned to mooring activities are not trained in the LNG associated hazard. Also, in contrast to LNG carrier crews, which are covered by the STCW convention, in terms of training, it was noticed a lack of recognized training programs for Algerian terminal workers, such as the Marine Terminal Operator Competence and Training Guide (MTOCT) (OCIMF, 2021).

It was also revealed during interviews that some CEOs do not apply the board of directors' training plan and prefer to pay taxes instead of spending the budget allocated for employee training. These was evidenced by quantitative findings, which illustrate the high relationship between the safety of operations as a dependent variable and safety training as an independent factor, with the most significant value of ".648". Therefore, the training of employees engaging in LNG ports and marine terminals must be a priority for leaders and managers. Aa stated by Dingledey (2017) enhanced hazard awareness and preparation, employee training, emergency situations, drills, and information exchange across organisations are all indispensable. Also, the adoption of the OCIMFs Marine Terminal Operator Competence and Training Guide by will help terminal operators in a) identifying the necessary skills for marine terminal personnel responsible for the safety of the ship-to-shore interaction, including supervisors and operators; b) evaluating the expertise of marine terminal personnel; c) determining the training requirements personnel; d) creating suitable learning programmes to meet training demands. Moreover, according to (ISO 28640:2010), terminals should guarantee that terminal personnel are educated in ship/shore LNG operations to ensure the safety of cargo handling operations. As well as assigning qualified personnel to manage the ship-to-shore interface and associated issues. Furthermore, governing bodies and senior management must also provide enough resources for professional training requirements (ISO 31000:2018). This can be achieved by multiplying joint drills and exercises with all LNG terminal stakeholders, namely, ports, operators and vessels.

4.3.3.4 Safety Communication

Table 18 *Frequency Table of Safety Communication*

Items	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Q29	3.7%	22.0%	40.2%	32.9%	1.2%
Q30	6.1%	17.1%	37.8%	32.9%	6.1%
Q31	6.1%	14.6%	45.1%	32.9%	1.2%
Q32	7.3%	39.0%	25.6%	25.6%	2.4%
Q33	3.7%	36.6%	25.6%	29.3%	4.9%
Mean	5%	26%	35%	31%	3%

Safety communication is also a very important factor for safety management of the ship-port interfaces. Taking into consideration the particularity and characteristics of LNG, any lack of communication during cargo operation may have severe repercussion. According to table 18, responders consider that safety communication in LNG ports and marine terminals in Algeria is ineffective and should be enhanced. Mean results show that just 31% of participants strongly agree and agree that communication is efficient. However, 35% disagree and strongly disagree. In addition, 35% are not fixed about the situation of communication in their organisations. Interviewees further highlighted the problem of communication misunderstanding, particularly during LNG transfer at the LNG terminal, including marine operations. They suggested particular attention to communication training for the ship-port interface staff, which will help involved parties communicate in the same way and use the same vocabulary. This includes safety information sharing, such as contingency plans, and safety meeting before commencing loading, where all safety measures can be discussed and fixed. In addition, personnel involved in marine services such as pilots, port authority, tugboats and mooring-mem are concerned. For instance, LNG/C captains, as long as they are responsible for approaching manoeuvers to the terminal, suggests the use of English language during port operations (pilotage, towage, mooring), allowing them to understand instantaneously the evolution of processes. In terms of data exchange, they also, declared that the mooring hooks at the LNG berths are not fitted with load sensors and tension monitoring data system.

When investigating quantitative data, it was deduced that a high correlation exists between the safety of operation and safety of communication factor with an important value of .609, including the high relationship with leadership safety commitment. With the value of .506. According to Hopkin (2018b), lack of establishing and communicating a precise risk management plan may result in a considerable failure in managing appropriately an organization's risks (Hopkin, 2018b). Therefore, establishing communication and consultation system in Algerian LNG terminals is more than necessary in order to enhance ship-port safety management. In line with ISO 31000:2018, leaders and managers should adopt a properly approved communication strategy, which includes disseminating information to different stakeholders and considering their feedback and expectation in decision making. Safety managers must maintain communication, teamwork, and cooperation with all involved parties (Labaka et al., 2016).

Concerns of stakeholders over the LNG cargo operations compel a risk assessment and communication essential components of the LNG port and marine terminal process. To prevent hazards, the LNG sector continually identifies new threats and revises design guidelines, technical standards, and operational processes. These suggested enhancements are originally communicated by associations such as SIGTTO and OCIMF. However, these standards are not applied in Algerian LNG ports and marine terminals. Hence, it is vital for safety managers in LNG ports and marine terminals to pay close attention to adopting norms and standards issued by recognized organizations in the LNG sector, such as OCIMF and SIGTTO.

4.3.3.5 Safety Improvement

Table 19 *Frequency Table of Safety Improvement*

Items	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Q34	23.2%	30.5%	26.8%	18.3%	1.2%
Q35	9.8%	20.7%	51.2%	17.1%	1.2%
Q36	3.7%	17.1%	47.6%	28.0%	3.7%
Q37	8.5%	20.7%	47.6%	22.0%	1.2%
Q37	8.5%	20.7%	47.6%	22.0%	1.2%
Mean	11%	22%	44%	21%	2%

The study results revealed that Algerian LNG ports and marine terminals are not continuously enhanced. As displayed in table 19, a mean of 44% of responders do not know whether there is continual improvement or not. Also, when answering Q36, only 20.8% of responders strongly agree and agree that there is a safety enhancement in Algerian LNG terminals. In contrary 31.7% disagree and strongly disagree, in parallel about 47.6% preferred answer neutral. However, interviews confirmed that currently Algerian LNG ports and marine terminals face a business as usual status. According to participant 8, several non-conformities remain untreated despite multiple reports. Moreover, participant 7 pointed out maintenance issues in regards to mooring equipment located in the dolphin and jetty, particularly (mooring hooks and capstans), including lighting concerns, which necessitate rigorous inspections and maintenance. Also, lack of carrying out audits and inspections jointly with all concerned parties (ship, port, and terminal) was outlined. Other participants stated that there is no punishment when rules are violated. Usually, if the organization does not move forward, it will move backwards. Accordingly, managers and responsible should focus their attention to this critical element. They should implement well-thought-out systems that not only address the present issue but are also suitable for the next expansion stage. This involves a significant level of self-awareness of top management (Greiner, 1998).

The correlation results evidenced that, safety improvement factor is very important to enhance safety in LNG ports and marine terminals. With a value of ".523" safety improvement is considered as key element for safety of operations. The results showed also that safety improvement has a strong relationship, with the other factors, namely, leadership safety commitment, safety training and safety communication, respectively with values of ".617", ".451" and ".312", which deduces that the continual improvement for LNG ports and marine terminals is vital not only for the safety of operations but also for all organization activities.

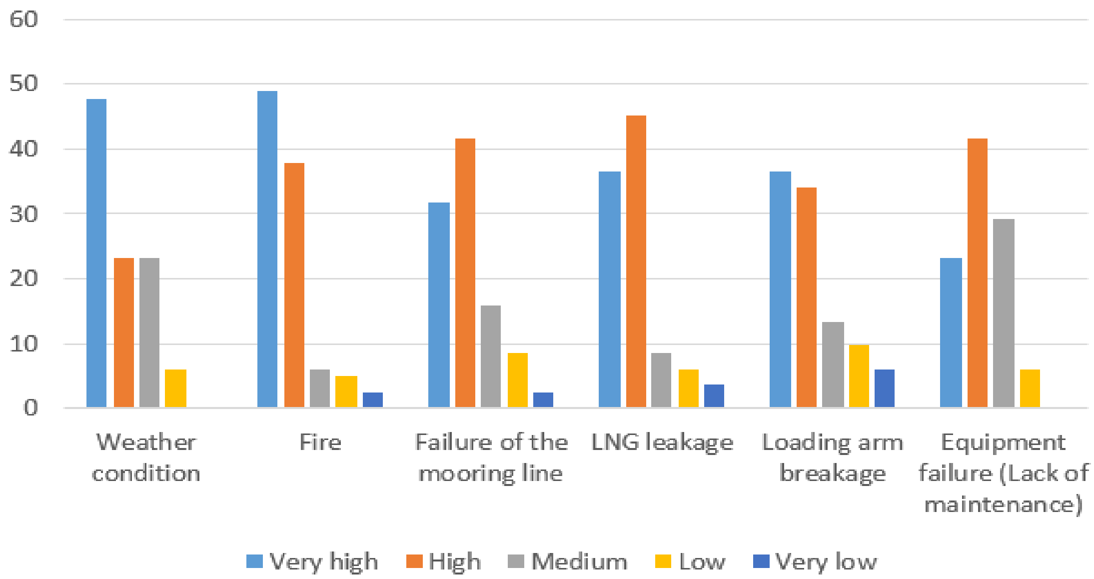
In line with (ISO 31000:2018) continual improvement is essential principles for risk management system. Risk is not a static issue. Thus, learning and continual enhancement are essential. Eventually, the interactive nature of port hazards involves regular updates of risk management systems, which includes an awareness among which components should be addressed for evolution to be effective (Justice, 2018). This can be achieved by an efficient evaluation, which is a fundamental part of the risk management framework, through a regular assessment of the risk management framework's performance over objectives, indicators and action plans and by determining if goals remain appropriate and achievable for the organization.

4.3.3.6 Potential Hazards in Algerian LNG ports and marine terminals

Table 20 *Potential Hazards Survey Result*

Hazards	Very high	High	Medium	Low	Very low
Weather condition	47.6	23.2	23.2	6.1	0
Fire	48.8	37.8	6.1	4.9	2.4
Failure of the mooring line	31.7	41.5	15.9	8.5	2.4
LNG leakage	36.6	45.1	8.5	6.1	3.7
Loading arm breakage	36.6	34.1	13.4	9.8	6.1
Equipment failure (Lack of maintenance)	23.2	41.5	29.3	6.1	0

Figure 18 *Ranking of Hazards per Order of Importance*



During quantitative data collection, participants were asked to classify hazards per order of importance considering the following criteria: likelihood or probability, gravity and consequences. Table 20 and figure 17, illustrate the potential hazards in Algerian LNG terminal ordered by participants engaged in LNG ports and marine terminals. The hazards were ranked as follows: 1) Fire, 2) LNG leakage, 3) Failure of mooring line, 4) Weather conditions, 5) Loading arm breakage, 6) Equipment failure.

When addressing the same question, the interviewees provided the same ranking order. However, they highlighted the lack of conducting risk assessments with appropriate documented methods or procedures. Figure 17 below shows ranking of hazard as per importance (very high, high, medium, low, very low)

Based on literature, hazards involved in LNG accidents are almost similar. Lessons learnt from past accidents demonstrated that hazards might negatively impact the safety of operations, resulting in catastrophes with severe economic, financial, and environmental consequences. (Fan et al., 2021). For instance, in 2004, the tragedy of Skikda LNG terminal, resulted in the deaths of 27 people and the injuries of more than 100 others, has contributed to the ongoing issue of the safety of LNG terminals (Junnola Jill et al., 2004). Prevention is better than cure. As a result, leaders and managers in Algerian LNG terminals, must pay a close attention in assessing potential hazards in LNG sector, in particular, those emphasised by professionals and experts in this study. There are several methods to assess risks (Justice, 2018). According to researchers, port employees fail to perform risk assessments owing to the absence of proper approaches and assessment tools (Kadir et al., 2017b). Nevertheless, risk assessment in LNG ports and marine terminals are essential for maintaining the sector's safety, security, and commercial performance (Elsayed, 2010a; Animah & Shafiee, 2020).

The Marine Terminal Management and Self-Assessment (MTMSA) standard has been established by OCIMF tool for worldwide use to enable terminals managers in assessing the performance of their management systems for berthing operations and the management of the ship/shore interface (OCIMF, 2012b)

As per (ISO 31000:2018), Risk assessment include risk identification, risk analysis, and risk evaluation. It should be undertaken methodically, continuously, and cooperatively, relying on the expertise stakeholder’s feedback, using the most up-to-date information, and supplementing it as required with additional investigation.

Chapter 5: Conclusion and Recommendations

5.1 Summary and Conclusions

Ports and terminal operators are crucial actors in shipping sector (CBS Maritime, 2015). Various ports comprise cargo-specific terminals, including LNG terminals where liquefied natural gas is handled at –162 °C from land-based to sea-based transportation and conversely. In addition, the ship-port interface is a critical link in LNG cargo operations (Rajewski et al., 2012), involving hazards that may cause severe repercussions to workers, infrastructure, and the surrounding area.

Algeria's LNG ports and marine terminals are vital to the country's economic growth since they constitute the primary means of 95% of hydrocarbon exportation (Camporeale et al., 2021). Through the start-up of the Arzew LNG terminal in 1964, Algeria became the first LNG exporter, and has since become among the leading world producers of natural gas (Foss, 2012). However, Algeria's LNG ports and marine terminals have been in operation for more than five decades, thus, requiring particular attention to the safety system applied for these infrastructure.

Academic studies have developed frameworks, methodologies, risk management standards and techniques, simulations, and models to tackle maritime hazards, identifying, evaluating, and proposing solutions that may assist policymakers and the sector (Schröder-Hinrichs et al., 2020). Therefore, with the aim of enhancing the safety management at LNG ports and marine terminals in Algeria, this research attempted to point out hazards that may lead to accidents within LNG terminals operations. This include the ship-port interfaces. This study used ISO 31000: 2018 standard as a framework to investigate safety management gaps. It also identified the main factors that may affect the safety in the ship-port interface.

A mixed method was applied, combining simultaneously a qualitative and quantitative. Around 250 potential candidates were contacted through email, networking platforms, and phone. Eventually 82 people answered the survey, and 10 experts were interviewed.

The information gathered from literature demonstrated that as a cryogenic substance with a very low temperature (-162 °C), LNG is very hazardous. When it is transported, handled, and stored, the threats multiply, and might pose potential harm to the people and material used for its manipulation. Based on the literature, the researcher identified several LNG-related hazards. The findings showed that almost all LNG-related hazards were similar (see box 1). However, the analysis of accidents between 1944-2022 indicated that the highest number of accidents related to LNG occurred in the ship-port interface in marine terminals during cargo transfer. Therefore, the gap found in the literature and triggering this study was confirmed by these findings. In particular, about 26 accidents out of 75 cases recorded happened during the ship-port interaction, representing 35% of the total. Hence, the identified threats in the literature should be considered during the assessment process at Algerian LNG ports and marine terminals, particularly, in the ship-port interfaces.

Based on literature review and using partially ISO 31000:2018 as framework, a conceptual framework was developed containing five safety management related factors, including safety of operations, leadership safety commitment, safety communication, safety training, and safety improvement (see section 2.8). These factors were used to develop the questionnaire survey and interview questions (Annex 2 & 3 refer). Quantitative data analysis was performed via SPSS software, which generated five factors. This was aligned with the same variables designed in the conceptual framework. Some of items of the factors were excluded because they failed to load in any factor. The main factors identified through the analysis are: a) safety of operations, b) leadership safety commitment; c) safety communication; d) safety training; e) safety improvement.

Given that the study focus was on Algerian ports, the findings of both qualitative and quantitative analysis concluded that the ship-port safety management in Algerian LNG ports and marine terminals is significantly linked to the above-mentioned factors. The correlation analysis results displayed that there are very high relationships between safety of operations variable and the rest of variables, including a considerable correlation among the factors them-self. Moreover, interview results confirmed this statement, deducing that the factors identified while developing the conceptual framework constitute an essential parameter in measuring and enhancing safety management in LNG ports and marine terminals. The results corroborated the conclusion of John et al. (2014) stating that when assessing seaport operations risk groups might be categorized into operational, technical and technological, organizational, and environmental groups, depending on the nature of operation, circumstances, and consequences. Moreover, according to IRGC (2015), risk management needs effective governance in standardizing, monitoring, and enhancing existing processes, procedures, and communication modes.

With respect to the respondents' perception of safety management in Algerian LNG ports and marine terminals, it was evident that LNG ports and marine terminals in Algeria, to some extent, lack in terms of effectiveness. Regarding leadership's safety commitment, participants were unsatisfied and lamented the current situation. According to O'Dea and Flin (2001), without strong leadership and management engagement, it is impossible to establish a Safety Management System (SMS), effective operation accident prevention, and active safety communications. Therefore, based on the findings, enhancing the safety management of Algerian LNG ports and marine terminals requires leaders and managers to pay close attention to solid safety commitments. Also, findings showed a lack of effectiveness in the safety of operations. Respondents agreed to the existence of overlap of roles and responsibilities when it comes to the management at the ship-port interfaces, including the lack of risk assessments. As a result, managers are urged to detail safety procedures based on a risk assessment approach. In terms of training, and in order to improve LNG ports and marine terminals employees' competency, it is crucial to adopt training standards and programs issued by recognized organizations such as OCIMF and SIGTTO. In regards to safety communication, this should be improved, notably during ship-port interaction. The results showed a lack of communication in the ship-port interface. This includes safety information sharing. Therefore, the development of a structured communication and consultation strategy is more than necessary. Finally, Algerian LNG ports and marine terminals should regularly review and adapt their safety management systems in response to external and internal developments. This can be done via the application of the continuous improvement principle, which is key in maintaining and improving the safety of operations.

5.2 Recommendations

It is very important to highlight that, due to the increased demand of LNG internationally, and considering the recent suspension of LNG pipeline’s “North Stream” and the “Maghreb–Europe Gas Pipeline”, the frequency of LNG carrier’s movement across producing and consuming countries would definitely rise, thus contributing to LNG ports and marine terminals' safety hazards. This necessitates an effective safety management and a comprehensive risk management strategy capable of efficiently addressing various kinds of threats.

In regards to challenges and prospects to enhancing safety in the ship-port interface in Algerian LNG terminals, the results revealed that there is an immediate need for a new paradigm that blends the ongoing development for these kind of infrastructures. For Algerian Oil Company (SONATRACH), it is more than necessary to implement standards and tools issued by the voluntary associations OCIMF and SIGTTO, which have led the LNG terminals sector since 1970. This will enable the application of international procedures and best practices at Algerian LNG ports and marine terminals.

At global scale, enhancing safety management in the ship-port interfaces in LNG terminal can be achieved through the development of a specific safety management system, based on the aforementioned factors identified during this study. According to Kontogiannis et al. (2017), safety management systems are moving from a normative approach to a ‘self-regulatory' and 'performance-oriented' approach which is more proactive, participatory, and more connected with organization’s operations. In comparison to shipping industry, studies have recently illustrated that enforcement of the ISM Code in the shipping sector has contributed to improving the safety of operations and mitigating mishaps related human errors (Tzannatos & Kokotos, 2009;Tzannatos, 2010). Similarly, the International Ship and Port Facility Security (ISPS) Code has succeeded in ensuring that professionals from ports and terminals follow similar procedures globally. Such efforts signal that ports need to follow such a global safety approach.

5.3 Limitation and Suggestions for Further Research

The research's scope included managers and professionals from Algeria involved with LNG ports and marine terminals operated jointly by port authorities and the Algerian oil company, SONATRACH, located in Arzew and Skikda.

This small scale of the study participants seeks to make the study objectives more achievable, efficient and suitable. Nevertheless, the focus on Algerian LNG ports and marine terminals restricts the findings from being generalized to global ports and other cargo-specific terminals.

It is also possible that other relevant respondents who did not participate in this research may have different safety management expertise and know-how than the respondents, have not participated in the study, which results in the limitation of this study. In addition, the study approach was to measure the perception of respondents, which might be subject to some bias.

In terms of future research, the results of this study encourage the necessity for a broader data collection and extend the study to a global scale, e.g. other case studies for other ports and cargo-specific terminals. It is also suggested that different research methodologies, e.g. focus groups, may be conducted, which indeed may improve, enlarge, or deny the current conclusions.

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Annex 1 : WMU Research Ethics Committee Protocol

WMU Research Ethics Committee Protocol

Name of principal researcher:	Benyebka CHERIGUI
Name(s) of any co-researcher(s):	None
If applicable, for which degree is each researcher registered?	Maritime Safety and Environmental Administration
Name of supervisor, if any:	Dr. Anish Hebbar
Title of project:	Port safety management – Case Study of Algerian LNG Terminals.
Is the research funded externally?	No
If so, by which agency?	No
Where will the research be carried out?	The research will be carried out in Sweden. The participants are from Algeria.
How will the participants be recruited?	The participants will be recruited by email on a voluntary basis.
How many participants will take part?	Around 200 participants
Will they be paid?	No
If so, please supply details:	No
How will the research data be collected (by interview, by questionnaires, etc.)?	The research data will be collected by questionnaire and personal interviews.
How will the research data be stored?	The research data will be stored on my personal computer with protected passwords.
How and when will the research data be disposed of?	All the research data will be deleted from my PC by the end of my MSC degree (31 October 2021).
Is a risk assessment necessary? If so, please attach	No

Signature(s) of Researcher(s): .... Date:

Signature of Supervisor: .... Date: 16 June 2022

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Please attach:

- A copy of the research proposal
- A copy of any risk assessment
- A copy of the consent form to be given to participants
- A copy of the information sheet to be given to participants
- A copy of any item used to recruit participants

Annex 2 : Survey Questionnaire

Dear Participant,

The purpose of this survey questionnaire is to investigate how the safety is managed in the ship-port interface, particularly in LNG terminals. This is part of my Master's dissertation at the World Maritime University (WMU). The result of this work would help boosts to further improve our understanding of how safety management should properly work in reality.

In this questionnaire, the Participant is invited to respond to 34 questions in 5 sections.

The information gathered in the survey is entirely anonymous. There will be no way of tracking down any responses to individuals, organisations, or vessels. As a student at WMU, I shall conduct my study following the World Maritime University (WMU) requirements for ethical research, which preserve your right to anonymity, among other things. I will be the only one who handles the completed forms or has access to the data. Data would be deleted on 31 October 2022 on graduation from the World Maritime University.

It is vital to get as many individuals to fill out the survey as possible to improve its quality. Completing the form will take roughly 15 minutes. It is also essential to answer the questions as you truly perceive the subject of the question. When answering the questions on the form, please ensure that your responses are relevant to the situation on your specific organization.

This survey can be filled out using the following link; however; if you have filled the paper version, please deliver it to the survey's designated contact person Benyebka CHERIGUI w1803113@wmu.se.

Please do not hesitate to contact me if you have any questions, comments, or recommendations about this survey.

Please accept my gratitude in advance for taking the time to complete the survey.

Sincerely yours.

Participant Background and Information:

1. Gender: ☐ Female ☐ Male
2. Age: ☐ Under 25 years ☐ 26-35 years ☐ 36-45 years ☐ 46 – 55 years ☐ Above 56 years
3. Organisation (company): ☐ SONATRACH - Arzew ☐ SONATRACH-Skikda ☐ Port of Arzew ☐ Hyproc Shipping Company ☐ Other
4. Service: ☐ Port Authority ☐ Pilotage ☐ Towage ☐ Production ☐ HSE ☐ Others
5. Position:……………………..
6. Experience in this position: less than 5 years/ 5-10 years/ 11-15 years/16-20 years/ More than 20 years.
7. Experience in the LNG ports and marine terminal: less than 5 years/ 5-10 years/ 11-15 years/16-20 years/ More than 20 years.

Please answer the following questions related to the situation in your **port / terminal** as perceived by you. The answers are five scales:

Questions	**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly agree**
Leadership and Commitment					
Q 1. The top management displays a strong commitment to enhancing safety	1	2	3	4	5
Q 2. The top management prioritizes safety over commercial activities.	1	2	3	4	5
Q 3. The top management ensures that risk management is integrated into all relevant operations	1	2	3	4	5
Q 4. The necessary resources are allocated to managing safety.	1	2	3	4	5
Q 5. When safety concerns are brought to the attention of the top management, we receive positive feedback.	1	2	3	4	5
Q 6. There is no punishment when safety rules are violated.	1	2	3	4	5
Q 7. There is a reward policy initiative for the employee to improve safety.	1	2	3	4	5

Q 8. The authorities, responsibilities and accountabilities are assigned to the appropriate and relevant persons at different operation/administration levels.	1	2	3	4	5

Safety of Operations

Q 9. The Safety procedures are readily available	1	2	3	4	5
Q 10. The Safety procedures can be easily comprehended	1	2	3	4	5
Q 11. The port authority ensures the safety operations of the ship-port interface	1	2	3	4	5
Q 12. The operator ensures the safety operations of the ship-port interface	1	2	3	4	5
Q 13. Superiors do not permit to perform work if there is a safety issue.	1	2	3	4	5
Q 14. Safety actions are carried out only when accidents/incidents occur	1	2	3	4	5
Q 15. The accidents, incidents and near misses are reported verbally to the top and/or middle management.	1	2	3	4	5
Q 16. The near misses are reported in writing to the top and/or middle management.	1	2	3	4	5
Q 17. The risk assessment is carried out before performing duties					
Q 18. The employees' risk awareness level is very high	1	2	3	4	5
Q 19. The workforce is adequate to ensure duties in good safe conditions	1	2	3	4	5
Q 20. Working and rest hours are adequate resulting in the carrying out of tasks in a safe manner.	1	2	3	4	5

Q 21. The employees conform to the required protective equipment.	1	2	3	4	5
Q 22. During ship's berthing, the pilot disembarks before the accomplishment of the mooring operation.	1	2	3	4	5
Q 23. The mooring equipment fixed in the terminal and the berthing structures are regularly maintained and inspected.	1	2	3	4	5
Q 24. The mooring pattern are regularly monitored during handling operation.	1	2	3	4	5

Safety Training

Q 25. Safety management training is conducted periodically and continuously	1	2	3	4	5
Q 26. Risk management training is conducted periodically and continuously	1	2	3	4	5
Q 27. Exercises (drills) and simulations are carried out regularly in our port/ LNG terminal.	1	2	3	4	5
Q 28. The staff training is sufficient to handle critical and hazardous situations.	1	2	3	4	5

Safety Communication

Q 29. The lessons learned from incidents and accidents, are shared with all the involved parts in port / LNG terminal.	1	2	3	4	5
Q 30. We are informed about accidents or incidents that occurred in other ports/ LNG terminals.	1	2	3	4	5
Q 31. Safety measures are discussed, communicated and shared effectively with our stakeholders.	1	2	3	4	5
Q 32. The emergency response plans are clearly displayed and communicated to those concerned.	1	2	3	4	5
Q 33. Safety meetings are frequently carried out with different services to discuss and share safety measures.	1	2	3	4	5

Safety Improvement					
Q 34. The safety internal audits and inspections are carried out regularly.	1	2	3	4	5
Q 35. The safety external audits and inspections are carried out regularly.	1	2	3	4	5
Q 36. There is a continuous improvement in safety in our port/ LNG terminal	1	2	3	4	5
Q 37. The non-conformities and observations noted through audits and inspections are treated and tracked until their close-out.	1	2	3	4	5
Q 38. Please specify among the criteria below which ones you use for risk assessment in your organization? □ Gravity □ Probability □ Consequence □ Not Applicable □ Other ………..					
Q 39. Please specify which of the risks below do you consider to be the highest risks during LNG handling operations? Please specify your choices in the order of their importance, starting with the highest risk, taking into account the criteria mentioned in the previous question.					
Q 40. Please specify any other risks you consider important during handling operations at LNG terminals?					
Q 41. Additional comments or recommendations about ship-port safety management in LNG terminals?					

Annex 3 : Interview Questionnaire

Interview Consent Form

Date of interview:

Duration of interview:

Research Project title: Port Safety Management - case study of Algerian LNG Terminals.

Research participant name:

Researcher investigator name:

Dear Ms/Mr.

Thank you for agreeing to be interviewed as part of my research project, which is a partial fulfilment of the requirements for the Master's degree of Science in Maritime affairs at the World Maritime University (WMU) in Malmo, Sweden.

Ethical procedures for academic research undertaken from the WMU require that interviewees explicitly agree to being interviewed and how the information contained in their interview will be used. This consent form is necessary for us to ensure that you understand the purpose of your involvement and that you agree to the conditions of your participation. Would you therefore read the accompanying information sheet and then sign this form to certify that you approve the following:

- Your interview will be recorded and a transcript will be produced.
- The transcript will be sent to you to provide you with the opportunity to correct any factual errors.
- Mr. Benyebka CHERIGUI as research investigator will analyse the transcript.
- The access to the interview transcript will be limited to researchers and academics involved in the research process.
- The information provided will be used for research purposes and will form part of the research reports or/and academic paper as well as eventually in presentations.
- Any extract or quotation of the interview used for publicly available publication will be anonymized.

Moreover, you have the right to stop the interview or withdraw from the research at any time, and your personal data will be immediately deleted on your request.

Anonymized research data will be archived on a secure drive linked to a World Maritime University email address. All the data will be deleted after completion of the research.

Quotation Agreement:

I also understand that my words may be quoted directly. With regards to being quoted, please initial next to any of the statements that you agree with:

	I wish to review the notes, transcripts, or other data collected during the research pertaining to my participation.
	I agree to be quoted directly.
	I agree to be quoted directly if my name is not published and a made-up name (pseudonym) is used.
	I agree that the researchers may publish documents that contain quotations by me.

By signing this form, I agree that;

1. I am voluntarily taking part in this project. I understand that I don't have to take part, and I can stop the interview at any time;
2. The transcribed interview or extracts from it may be used as described above;
3. I have read the Information sheet;
4. I don't expect to receive any benefit or payment for my participation;
5. I can request a copy of the transcript of my interview and may make edits;
6. I have been able to ask any questions I might have, and I understand that I am free to contact the researcher with any questions I may have in the future.

Participant's name and signature: Date:

Contact Information:

This research has been reviewed and approved by the World Maritime University Research Ethics Committee. If you have any additional questions or concerns about this project, please contact:

Student's name: Benyebka CHERIGUI

Specialization: Maritime Safety and Environmental Administration (MSEA).

E-mail: w1803113@wmu.se

You can also contact research supervisor:

Supervisor's name: Dr. Anish Hebbar

Position: Assistant Professor, MSEA

E-mail: ah@wmu.se

Your participation in the interview is highly appreciated.

S No	Questions	Harbour Master	PFSO	Marine Pilot	Safety Manager	Loading Master	TUG Master	LNG Ship's Captain
Leadership and Commitment								
1.	How do you describe the safety management policy and top management commitment in your port/terminal?	x	x	x	x	x	x	
2.	How would you describe the balance between safety and commercial activities in your port / Terminal?	x	x	x	x	x	x	
3.	Could you describe how the decision-makers of your port/terminal can identify and evaluate different alternatives and risks involved?	x	x	x	x	x	x	
4.	Could you elaborate on how Stakeholders' opinions and perceptions are taken into account in decision-making in terms of safety management in your port/terminal?	x	x	x	x	x	x	
Safety Management Process								
5.	How do you describe the situation of safety management in your port/terminal?	x	x	x	x	x	x	
	How do you describe the situation of safety management in the Algerian LNG terminal?							x

6.	What is your opinion about current Algerian legislation related to safety management in port/terminal?	x	x	x	x	x	x	x
7.	Could you discuss the challenges yet to face in an effort to enhance safety management in your port,/terminal? how can efficient port/terminal management contribute to overcoming those challenges?	x	x	x	x	x	x	
8.	Could you discuss the main safety hazards in your port /Terminal?	x	x	x	x	x	x	
	Could you discuss the main safety hazards in Algerian LNG Terminal?							x
9.	What do you perceive as the most serious threat to the port / LNG terminal in the next five years? why?	x	x	x	x	x	x	x
10.	Do you think that the port/terminal's Employees are aware of the risks they are accountable for? Could you describe the basis for your opinion?	x	x	x	x	x	x	x
11.	If there were infringements to the safety regulations and violations by the team under your supervision? What are the drivers behind these violations?	x	x	x	x	x	x	x
Safety Management Competence								
12.	In your opinion what is the level of employee safety training in your port/terminal? Could you describe the basis for your opinion?	x	x	x	x	x	x	
13.	Could you discuss the different safety training, conferences or seminars you received during the last five years?	x	x	x	x	x	x	
14.	In your opinion, what type of training is recommended to employees in order to enhance safety in your port/terminal? Could you describe the basis for your opinion?	x	x	x	x	x	x	

Safety Management Information flows								
15.	Could you elaborate on safety Information flows to port/terminal employees and stakeholders?	x	x	x	x	x	x	x
16.	What are the major challenges in terms of communication to enhance safety management in port/terminal?	x	x	x	x	x	x	x
Safety Performance Measurement and Continual Improvement								
17.	What do you need to improve the safety management in your port/terminal? Could you describe the basis for your opinion?	x	x	x	x	x	x	
18.	What does need to improve the safety management in the Algerian? Could you describe the basis for your opinion?							x
19.	Do you think that the implementation of ISO safety standards or another specific tool or guideline sorts out safety issues in your port /terminal? Could you describe the basis for your opinion?	x	x	x	x	x	x	
20.	What are the main barriers behind not having proper safety management in your port/terminal? What do you think are the solutions for such barriers?	x	x	x	x	x	x	
21.	Do you think that the implementation of safety standards sorts out safety issues Algerian LNG terminal? Could you describe the basis for your opinion?	x	x	x	x	x	x	x
22.	How are performed safety audits in your port/terminal and if any recurrent observations are noted how do you track and monitor the close-out of observations?	x	x	x	x	x	x	