10-28-2023

A system thinking approach and novel framework towards safe pilot transfer arrangements

Eslam Ramadan Badry Gad

WORLD MARITIME UNIVERSITY

A SYSTEM THINKING APPROACH AND NOVEL FRAMEWORK TOWARDS SAFE PILOT TRANSFER ARRANGEMENTS

ESLAM RAMADAN BADRY GAD

EGYPT

A dissertation submitted to the World Maritime University in partial fulfilment of the requirements for the award of the degree of Master of Science in Maritime Affairs

2023

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): ....

(Date): Monday, 25th September 2023

Supervised by: Prof. Dr. Anish Hebbar

Co-Supervised by: Dr. Serdar Yildiz

Supervisor's affiliation: World Maritime University

Co-Supervisor's affiliation: World Maritime University

Dedication

This dissertation is dedicated to the memory of the maritime pilots who tragically lost their lives in the line of duty and their grieving families who carry their legacy forward.

It also pays homage to the maritime pilots worldwide. I fervently hope this research ensures that all maritime pilots return home safely.

May your transfers always be SAFE…

Acknowledgements

In the Name of Allah, the Most Gracious, the Most Merciful,

I begin this acknowledgement with praise and gratitude to Allah for bestowing upon me the opportunity to embark on this academic journey at WMU, and for granting me strength and guidance. It is through His blessings and mercy that I have reached this milestone.

I extend my heartfelt appreciation to the World Maritime University. The guidance, knowledge, and mentorship provided by WMU's dedicated professors have been instrumental in shaping my academic and professional journey. I am deeply thankful to WMU and its esteemed professors for their unwavering support, dedication, and contributions to my journey. I also express my gratitude to the IMO for their financial support and for granting me the scholarship for this esteemed experience.

I extend my deepest appreciation to my dissertation supervisor, Professor Anish Hebbar, and co-supervisor, Dr. Serdar Yildiz, for their unwavering support, mentorship, and expertise. Their guidance has been instrumental in shaping the trajectory and quality of this research.

To my wife Marwa for her support, patience, and understanding throughout this challenging journey. Her encouragement, sacrifices, and belief in my dreams have been my constant motivation. Her love is the cornerstone of my strength...

To my precious little daughters, Karma, Alia, and Layal, who have brought boundless joy and inspiration into my life. Your laughter and innocent curiosity have been my source of joy amidst the demands of academia. I hope to be a role model for you and teach you the importance of hard work, perseverance, and the pursuit of knowledge.

I express my heartfelt gratitude to my father, Captain Ramadan Badry, for instilling in me the values of determination and resilience. Your wisdom and unwavering belief in my abilities have been a guiding force in my life. I am forever indebted to you for your support. Without you, I would have done nothing. To my mother, Hanaa, whose love and prayers have been my source of strength. Your unwavering faith in my potential has been a driving force in my pursuit of education. I am grateful for your boundless love and encouragement.

I extend my sincere thanks to the Arab Academy for Science, Technology, and Maritime Transport for providing me with the opportunity to pursue this journey. I am deeply appreciative of the support and understanding I have received from Dr. Mohamed Dawood, Dr. Mohie El Sayeh, Dr. Ahmed Saad, and all my colleagues at the College of Maritime Transport and Technology. Their encouragement, flexibility, and belief in the importance of continued education have allowed me to pursue this academic endeavour.

This dissertation signifies the culmination of dedication and hard work, and I am profoundly thankful for the unwavering support and guidance I have received along the way. To all who have been part of this journey, to my friends and family, to my MSEA classmates, your contributions have been indispensable. Your unyielding support and understanding have been my anchor in the stormy seas of academia.

Abstract

Title of Dissertation: **A System Thinking Approach and Novel Framework Towards Safe Pilot Transfer Arrangements**

Degree: **Master of Science**

Pilot transfer arrangements in maritime operations have long been an area of concern due to the persistence of accidents that pose serious threats to pilot safety. This study addresses the pilot transfer arrangements accidents by adopting a system thinking approach to comprehensively analyse these accidents. Its primary objective is to provide a comprehensive understanding of the factors contributing to accidents in this specific domain. This analysis synthesizes the renowned Rasmussen risk management framework and the International Maritime Organization's Marine Casualty Investigation circular, establishing a robust analytical foundation for the study.

Despite the evolution of maritime accident analysis models dedicated to identifying deficiencies and improving overall maritime safety, the utilization of a system thinking approach in the context of pilot transfer arrangement accidents has thus far remained uncharted territory. This approach presents a holistic lens through which to analyse complex socio-technical systems, shedding light on the interactions between system components while pinpointing pivotal pressure points in the system.

The investigation of pilot transfer arrangements accidents was based on the procurement of 25 accident investigation reports. These reports underwent comprehensive analysis and were supplemented with semi-structured interviews to strengthen the research findings. Subsequently, the research findings were subjected to synthesis using various frameworks. However, these existing frameworks appeared to be inadequate in elucidating the intricate interrelationships contributing to failures in pilot transfer arrangement accidents. As a result, this inadequacy provided the impetus for the development of the novel framework.

In the culmination of this research, the study introduces the SAFEPILOT framework, designed to comprehensively address the factors contributing to accidents in pilot transfer arrangements and effectively eliminate them. The imperative for this innovative framework arises from the limitations encountered in the existing accident analysis models. Successful implementation of the SAFEPILOT framework will achieve the objective of achieving the highest standards of safety in pilot transfer arrangements and concomitantly reducing the associated risks.

KEYWORDS: Accident investigation, Pilot Transfer Arrangements, System Thinking Approach, STAMP model, Human and Organizational Factors, Marine Casualty Investigation, Maritime Safety Analysis

Table of Contents

List of Tables

List of Figures

List of Abbreviations

BMI	Body Mass Index
CREAM	Cognitive Reliability and Error Analysis Method
CIC	Concentrated Inspection Campaigns
CHIRP	Confidential Human Factors Incident Reporting Program
DPA	Designated Person Ashore
ECGs	Electrocardiograms
ETA	Event Tree Analysis
FMEA	Failure Mode and Effects Analysis
FBD	Fall Prevention Devices
FTA	Fault Tree Analysis
FSA	Formal Safety Assessment
FFPM	French Federation of Marine Pilots
GISIS	Global Integrated Shipping Information System
HSSC	Harmonized System of Survey and Certification
HEP	Human Error Probability
HFACS	Human Factors Analysis and Classification System
ICS	International Chamber of Shipping
SOLAS	International Convention for The Safety of Life at Sea
STCW	International Convention on Standards of Training, Certification And Watchkeeping for Seafarers
ILO	International Labour Organization
IMO	International Maritime Organization
IMPA	International Maritime Pilots Association
ISO	International Organization for Standardization
ISM	International Safety Management
ISPO	International Standards for Pilot Organizations
IUG	International Users Group

MAIB	Marine Accident Investigation Branch
MCI	Marine Casualty Investigation
MoU	Memorandum of Understanding
NGOs	Non-Governmental Organizations
PPE	Personal Protective Equipment
PSC	Port State Control
PTA	Pilot Transfer Arrangements
REC	Research Ethics Committee
SMS	Safety Management System
STAMP	System-Theoretic Accident Model and Processes
UKMPA	United Kingdom Maritime Pilot Association

Chapter 1: Introduction

1.1 Background

The shipping industry encompasses a wide range of tasks, all of which are essential for ensuring the success of a voyage. Within this multifaceted context, certain operations are particularly noteworthy due to their complexity and the inherent risks they pose during the operation. Pilotage activities, in particular, are renowned for their intricacy and the numerous hazards they entail. (Sharma & Nazir, 2017). Henceforth, pilots are exposed to heightened risks and potential accidents stemming from incidents related to transfer arrangements (Ernstsen et al., 2018; Sharma & Nazir, 2017; Uğurlu et al., 2017).

The origin of marine pilotage can be traced back to the ancient Greek book, "Periplus of the Erythraean Sea", written around A.D. 64, which describes the pilot as a merchant guide to the northern Indian Ocean and the Red Sea (Hignett, 1978). Currently, there are over 2900 ports and 4100 harbours worldwide, and most ships entering or leaving these ports are using pilot services (Lloyd's List, 2023).

Pilotage is essential to the international shipping industry, and its significance cannot be overemphasised. Despite the inherent risks associated with pilotage operations, it remains an indispensable service, and with it, the shipping industry's safety and efficiency are significantly protected. As such, the training, qualification, certification, and well-being of pilots are critical factors in ensuring the continued safety and success of the shipping industry (Tran, 2003). Pilots rely on pilot transfer arrangements to embark and disembark from vessels, and it is widely acknowledged that the pilot transfer operation represents the most perilous aspect of pilotage operation (Ernstsen et al., 2018; Sharma & Nazir, 2017; Uğurlu et al., 2017).

The International Maritime Organization (IMO) has established various regulations and recommendations to ensure the safety of the pilot transfer arrangements. Additionally, the International Organization for Standardization (ISO) has issued the ISO 799 series, offering non-mandatory pilot transfer operations recommendations (ISO, 2019, 2021, 2022). Moreover, the International Standards for Pilot Organizations (ISPO) was created to provide standardisation of the pilots' organisation (ISPO, 2023). In addition to the aforementioned regulatory bodies, the maritime pilot industry is supported by nine global associations, with a total of 689 organisations operating in 133 countries (Marine Pilots Community, 2023).

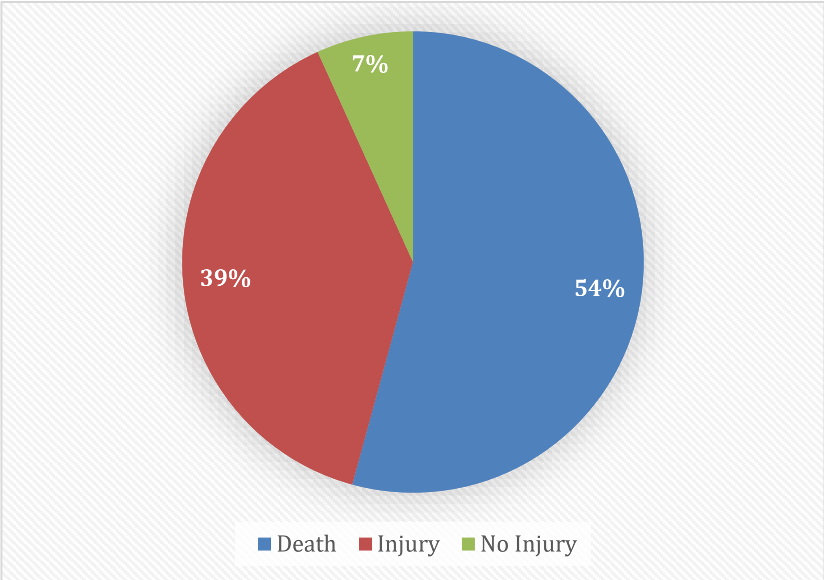
However, the pilot transfer arrangements regulations and standards in place, pilot transfer arrangement accidents have long been a long-standing issue due to the increase in the number of accidents and the severity of the consequences (Behforouzi, 2021; Meere et al., 2005; Nuutinen & Norros, 2009; Tunçel et al., 2022).

1.2 Problem Statement

Pilot transfer arrangement accidents are on a continuous increase. Murai et al. (2012) suggest an average fatality rate of once every three years. Behforouzi (2021) presents a more concerning figure of 2-3 annual fatalities. As per data from the French Federation of Marine Pilots (FFPM), there have been 160 recorded accidents over the past two decades, resulting in an average of approximately eight incidents annually (Gaillard, 2022). While according to the Marine Accident Investigation Branch (MAIB) annual report for 2022, there has been a significant surge in incidents and accidents related to pilot transfers, with over 400 documented cases (MAIB, 2023). Furthermore, the first six months of 2023 have already witnessed seven fatalities linked to maritime pilot transfer operations, as highlighted by Gosling (2023). It is imperative to underscore that this upturn in statistics raises concerns about the safety of these operations. Additionally, it is essential to acknowledge that the true extent of such incidents remains uncertain due to numerous unreported or unpublished cases (Aydin et al., 2022).

The repercussions of accidents involving pilot transfer arrangements can be categorised as both severe and highly serious. A visual representation of this classification, as depicted in Figure 1 and based on an overview of accident reports and notices spanning 1997 to 2023, underscores the gravity of these incidents.

Figure 1 Consequences of pilot transfer arrangements accidents



Note. By author based on data collected from public domain

In light of these findings, this study is undertaken with the objective of delving into the intricacies of pilot transfer arrangement accidents. It aims to dissect the contributing factors behind these incidents and engage in a comprehensive discussion on potential avenues for improvement, ultimately working towards enhancing the safety protocols and practices surrounding pilot transfer arrangements particularly and the maritime safety generally which aligns with the IMO World Maritime Theme for 2024 "Navigating the future: safety first!" (IMO 2022a)

1.3 Aim and objectives

This study aims to identify and highlight the current design and regulations flaws of pilot transfer arrangements and emphasise the importance of safety systems for pilots. The study further aims to synthesise a framework that can effectively mitigate the risk of incidents through a comprehensive analysis of the factors contributing to accidents in pilot transfer arrangements.

To achieve the research aim, the study progresses according to the following objectives:

- To analyse the root causes and contributing factors that result in pilot transfer arrangement accidents; and

- To identify and analyse current systemic gaps in the safety of pilot transfer arrangements within the maritime industry, particularly in relation to established frameworks; and

- To develop a framework for effectively utilizing the existing frameworks to assess and address safety deficiencies within pilot transfer arrangements system.

In order to achieve the research objectives, this study will answer the following questions:

- What is the role of responsible entities in shaping pilot transfer arrangements?

- What are the factors influencing the safety aspects of pilot transfer arrangements?

- What are the current systemic gaps in the safety of pilot transfer arrangements, and how can the extant frameworks be effectively employed for the assessment of gaps within pilot transfer arrangement?

1.4 Scope of work

This study adopts a system thinking approach to comprehensively analyse pilot transfer arrangement accidents. However, it is essential to define the boundaries of our research focus. Therefore, certain specific aspects are expressly excluded from the scope of this study:

- Helicopter-based pilot transfers: The investigation does not encompass pilot transfers facilitated by helicopters.
- Technical specifications of pilot boats: Technical details and specifications related to pilot boats are not within the purview of this study.
- Interactions between vessels and pilot boats: This study does not explore interactions between vessels and pilot boats that may lead to collisions, capsize incidents, or casualties.
- Accidents beyond pilot transfer arrangements: Accidents or fatalities occurring outside the defined scope of pilot transfer arrangements to and from vessels are excluded from this study's analysis.

The primary focus of this research centres on international regulations, standards, and guidelines governing pilot transfer arrangements. Local or regional regulations are intentionally excluded from this investigation to maintain a cohesive and manageable scope. By concentrating on international frameworks, it is aimed to provide valuable insights into safety measures that transcend specific regional contexts.

By establishing these boundaries and focus areas, this study aims to deliver an analysis of pilot transfer arrangement safety within its designated scope.

1.5 Disposition of the study

In order to achieve the aim of the study, the thesis consists of six chapters as follows:

Chapter 1 elaborates on the motivation and significance of this study. It emphasises the serious consequences of unsafe acts during the use of pilot transfer arrangements. Furthermore, the chapter highlights that a thorough safety investigation on the root cause(s) of pilot transfer arrangements accident is required, as well as the identification of underlying factors that are of critical importance to prevent the recurrence of similar accidents in the future. In this regard, the objectives and direction of this study are presented at the end of Chapter 1.

Chapter 2 consists of two sections. The first section pertains to regulatory analysis, wherein an in-depth examination of prevailing regulations governing pilot transfer arrangements is conducted. This part provides a comprehensive overview of the regulatory framework concerning pilot transfer arrangements and operations.

The second principal segment of Chapter 2 focuses on identifying prior research pertaining to pilot transfer arrangements, risk management, and accidents. This section aims to highlight gaps in the existing knowledge and shed light on the underlying reasons behind the persistent occurrence of accidents in this domain.

Chapter 3 provides an overview of the methodology, encompassing the system approach to examining pilot transfer arrangement accidents. And the various frameworks applied to identify accidents contributing factors. Additionally, it includes a description of the datasets used in the study, along with details about the analysis process employing the accident reports.

Chapter 4 covers risk management and relevant pilot transfer arrangements accident analysis findings that emerged from the integration of accident reports analysis and experts' opinions collected for this study and the statistical analysis aimed at identifying the active and latent factors that have contributed to pilot transfer arrangements accidents. The findings are presented in a framework at the end of Chapter 4.

Chapter 5 synthesises the findings into a conceptual framework through a comprehensive approach. This framework serves to ensure the safety of pilot transfer arrangements, providing safety assurance and accident prevention measures.

Finally, Chapter 6 presents the conclusions of the study, including limitations and further studies, and recommendations for improvement of maritime safety analysis and pilot transfer arrangements process.

Chapter 2: Analysis of pilot transfer arrangement operational standards and safety concerns

2.1 Introduction

Pilotage stands out as one of the most complex and crucial operations in navigation due to various risks (Sharma & Nazir, 2017). One of the dangers that impacts pilots is accidents involving pilot transfer arrangements (Tunçel et al., 2022). This chapter delves into analysing regulations and recommendations for pilot transfer arrangements. It then examines earlier research on pilot transfer arrangements and associated risks to uncover gaps in the previous studies.

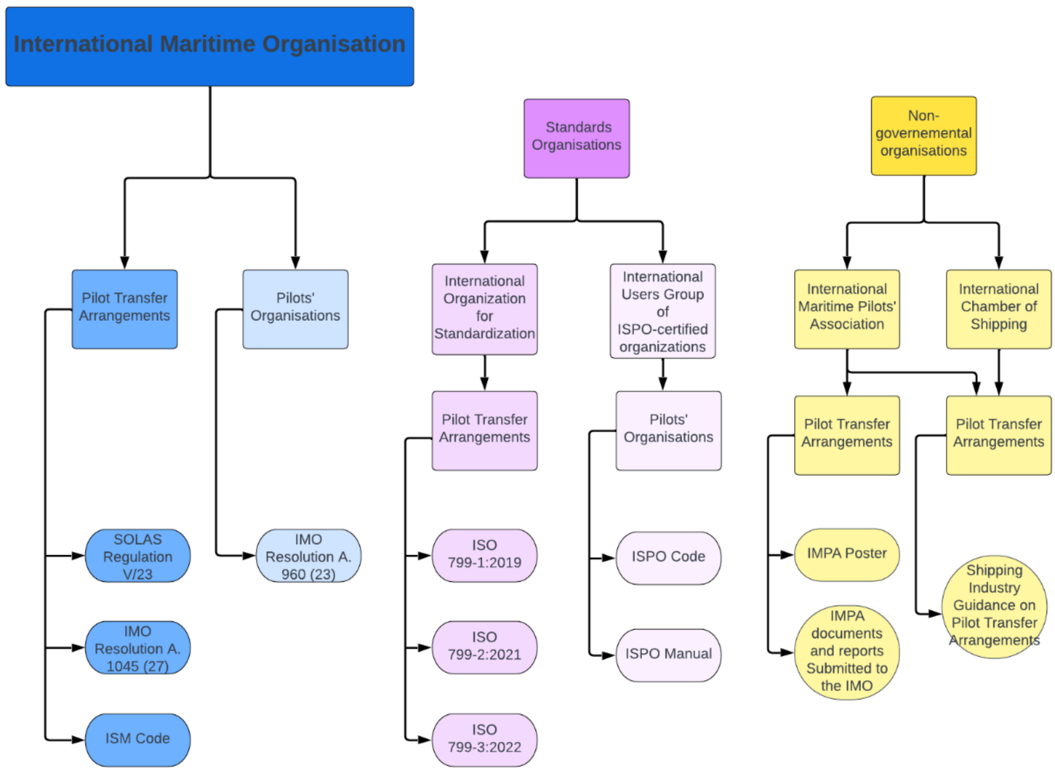
2.2 Navigational operations and pilotage procedures

Navigation in confined areas, such as ports and canals, requires personnel with exceptional knowledge to ensure the vessel's safety and environmental protection (Park et al., 2019). An experienced pilot with knowledge of the local area boards the vessel that enters or leaves the confined area to provide navigation advisory services to the master. In most seaports and canals, pilotage is mandatory, particularly for foreign or large vessels, due to safety security concerns and the strategic importance of those areas (Wu et al., 2020). Pilots usually join the vessel as it approaches the port area upon reaching the pilot boarding ground and disembark once the vessel is safely at berth. Similarly, during departures, pilots board the vessel at the berth and disembark when the vessel is departing the port area at the pilot boarding ground. Various methods are employed for pilot embarkation and disembarkation, with the most commonly utilised approach being the pilot ladders (Demirci et al., 2022).

Nevertheless, it is essential to note that boarding and disembarking from a ship involve hazardous operations, necessitating strict regulations to ensure the safety of pilots during transfer operation. As a result, pilot transfer arrangements and transfer operations fall under the purview of regulatory oversight by several governing bodies (Aydin et al., 2022; Tunçel et al., 2022).

A comprehensive review of the existing literature reveals the presence of three primary entities primarily responsible for shaping regulations and standards within this domain - a discussion of which will follow in subsequent sections. Foremost among these entities is the IMO, serving as the principal regulatory authority. This regulatory framework is further reinforced by supplementary standard-setting bodies and non-governmental organisations (NGOs), as visually represented in Figure 2.

Figure 2 Primary entities responsible for shaping pilot transfer arrangements and operations



2.3 IMO Regulations governing pilot transfer arrangements and operations

The pilot ladder is the primary equipment for the transfer of pilots between the pilot boat and the vessel. Numerous regulations have been implemented to establish specific requirements for the pilot transfer arrangements specifications and operations. These regulations aim to guarantee the safe execution of pilot transfers between the pilot boat and the vessel and vice versa (Radwanski & Rutkowski, 2022).

The International Convention for the Safety of Life at Sea (SOLAS), 1974, constitutes a cornerstone international agreement addressing various maritime safety aspects. Within Chapter V Regulation 23, SOLAS establishes the minimum requirements for pilot transfer arrangements. Furthermore, IMO Resolutions provides specific technical definitions for pilot transfer arrangements and operations.

2.3.1 SOLAS mandated regulations

The inception of pilot transfer arrangements can be traced to the fourth edition of SOLAS, established in 1960. Regulation 17/V stipulates that the secure positioning of the ladder against the ship's side determines a range of climbing distances from 1.5 to 9 meters. Specific parameters for the ladder's steps—48 cm in width and 2.5 cm in depth—were mandated. Furthermore, nighttime operations necessitate the provision of adequate lighting for the ship's side (IMO, 1960).

Since then, pilot transfer arrangements regulations have been updated and renumbered to the current SOLAS regulation V/23. It emphasises five essential components: pilot boarding arrangements, ship personnel's responsibilities in setting up pilot transfer equipment, associated equipment requirements, clear access, and adequate lighting (IMO, 2020).

One of the key outcomes of the SOLAS Convention with respect to pilot transfer arrangements is the establishment of specific requirements for pilot ladders. These requirements encompass the specifications of the maintenance and stowage, as well as the provision for a combination ladder, utilised when the distance from the water's surface to the ship's access point exceeds 9 meters. Notably, the convention mandates that the pilot ladder must have a minimum climb height of 1.5 meters. However, no regulations or standards exist for ships with a freeboard of less than 1.5 meters, leaving the determination of pilot transfer arrangements to the discretion of the vessel's master and pilot.

The SOLAS convention also emphasises the significance of certification, marking, and maintenance record-keeping. However, the regulations do not provide explicit guidelines regarding the maintenance or the required frequency of inspections. This lack of specific guidance could result in oversight by ship personnel. According to Tunçel et al. (2023), The impact of inadequate maintenance of pilot ladders and combination ladders on the frequency of related incidents cannot be ignored. The current regulations lack a systematic maintenance system that ensures the effective implementation of international safety management practices and employs internal and external monitoring mechanisms.

Inspections should be conducted to assess the overall condition of the pilot transfer arrangements, including critical components as mandated by SOLAS. However, a significant factor in pilot accidents underscores the importance of regulatory documentation and inspection to ensure safe and professional rigging, use, maintenance, and handling of pilot transfer arrangements (Broers, 2021). Notably, this gap in the regulations substantially contributes to a significant number of accidents (Aydin et al., 2022)

Regarding the illumination of the pilot transfer arrangements area, which is mandated in Regulation V/23.8, the light specifications are not determined in the regulation as it only mentions that adequate lighting is required. Meere et al. (2005) highlighted that a mere 3.8% of pilots habitually carry a flashlight and concluded that inadequate lighting ranks among the top five contributing factors to accidents related to pilot transfer arrangements.

The stanchions and safe access of pilots to the deck are one of the regulations under SOLAS regulation V/23. Despite the long-standing inclusion of these regulations in SOLAS since 1960, which aim to ensure the safe passage of pilots onto vessels, accidents resulting from inadequate stanchions continue to occur. In response to the rising number of non-compliance cases with these regulations and the subsequent accidents during transfer operations, the United Kingdom Maritime Pilot Association (UKMPA) emphasises the need for heightened attention to stanchion handhold provisions and spacing (UKMPA, 2023). The UKMPA circular highlights the ongoing concern regarding compliance with the regulations and the imperative of addressing the issue promptly. It underscores the necessity for effective measures to be implemented to prevent accidents and enhance the safety of transfer operations for pilots.

Moreover, SOLAS regulations stipulate that a designated responsible officer must oversee the rigging of pilot transfer arrangements and the pilot's embarkation. Nonetheless, the officer's specific roles and responsibilities remain unspecified within the pilot transfer arrangements regulatory framework.

2.3.2 Navigating IMO Documents: Bridging the gaps with external authorities and studies

As a step for enhancing the pilot transfer arrangements' safety, the pilot transfer arrangements were included in the Harmonized System of Survey and Certification (HSSC) as a part of the safety equipment certificate in IMO Resolution A.746(18), which was adopted on November 4, 1993 (IMO, 1993) and regularly updated till IMO Resolution A. 1156(32) (IMO, 2022b). Despite the procedure which makes the pilot transfer arrangements subject to checks during initial, annual, and renewal surveys as a part of the safety equipment certificate, it has neither improved compliance rates with the regulations nor reduced the number of accidents IMPA (2022).

Additionally, IMO Resolution A.1045 (27) Pilot Transfer Arrangements was adopted on November 30, 2011. It outlines minimum standards for pilot transfer arrangements.

The resolution provides specific requirements for the positioning, construction, and equipment used in these arrangements to ensure safe pilot transfers. However, the resolution annexe is titled Recommendation on Pilot Transfer Arrangements. In addition, the first paragraph states, "Ship designers are encouraged to consider all aspects of pilot transfer arrangements at an early stage in the design." Even though the data provided in the annexe are essential for ensuring the safety of the pilots, they only serve as guidelines and recommendations and are not mandatory.

Moreover, the Pilot Transfer Arrangements Resolution states that securing strong points, shackles, and securing ropes should be at least as strong as the side ropes. However, it lacks explicit usage concerning the use of shackles. Consequently, several authoritative bodies, including the Swedish Maritime Administration (2022), the Port of London Authority (2020), and the Tokyo Memorandum of Understanding (MoU) (2020), have issued Safety Bulletins addressing the utilisation of shackles to secure ladders at intermediate lengths. The Safety Bulletins emphasise the inherent safety risks and noncompliance with regulations associated with improper use of shackles. Similar concerns have been raised by the International Maritime Pilots Association (IMPA) (Palmers, 2020) and the Maritime Advisory Board of Confidential Human Factors Incident Reporting Program (CHIRP, 2020)

Using shackles to secure ladders at intermediate lengths introduces forces to ladder steps beyond their intended design and tested capabilities, as shown in Figure 3 as each step is only designed to accommodate the weight of a single pilot and is tested for a maximum force of 8 kN. In contrast, the side ropes, which are capable of supporting both the pilot and the ladder, undergo testing for a higher force threshold of 24 kN. In Figure 4 using shackles as part of the securing method introduces a considerable probability of ladder slippage when the pilot exerts full weight on the ladder (Vallance, 2020).

Figure 3 Faulty ladder, shackles exerting extra load on the wooden step

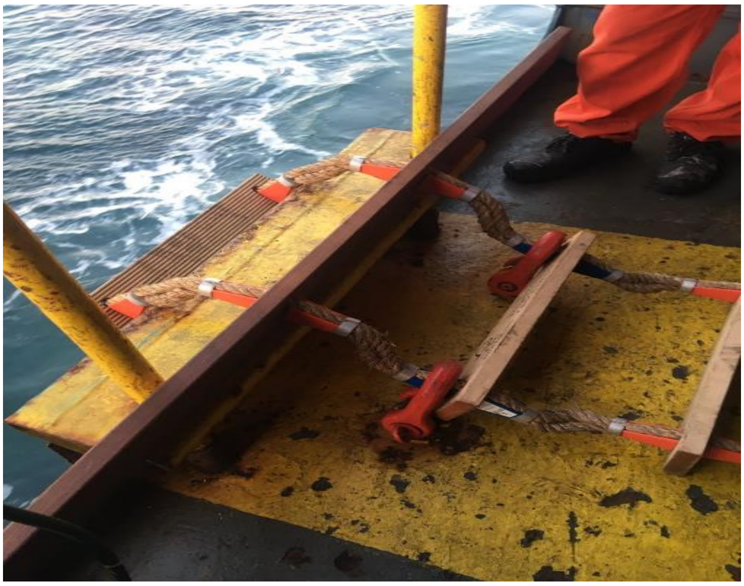


Figure 4 Faulty ladder, risks of ladder slippage when exerting weight

Additionally, a study was found to have been conducted by the University of Southampton to investigate the effectiveness and impact of various methods used to secure the ladders at intermediate lengths. It reveals that the use of shackles in pilot transfer arrangements had led to a series of damages. Finally, it concludes that the rolling hitch method showed signs of compression and discolouration on the side ropes but did not cause material damage (Symonds et al., 2023).

Despite the University of Southampton study's emphasis on the dangers of shackles and cow hitch knots and the effectiveness of rolling hitch knots, this is not reflected in any of the regulations or recommendations governing the pilot transfer arrangements.

Additionally, when it comes to the ropes, the Pilot Transfer Arrangements Resolution states that the side ropes should consist of two uncovered ropes with a diameter of not less than 18 mm on each side. The ropes must be continuous with no joints and have a breaking strength of at least 24 kN per side rope. Nonetheless, the static tests conducted to determine the 24 kN breaking strength do not encompass dynamic forces such as those caused by water drag or contact with the pilot boat.

Another IMO Resolution was issued by the IMO addressing the pilots' organisations side. The IMO issued Resolution A 960(23) titled Recommendations for Training and Certification and on Operational Procedures for Maritime Pilots Other Than Deep-Sea Pilots (IMO, 2004). The IMO Resolution A 960(23), specifically its Annex 1 detailing training and certification for pilots, omits training related to pilot transfer operations and safety. Instead, it focuses solely on pilotage operations' safety aspects concerning vessels and the environment, neglecting the pilots' own safety.

Additionally, the IMO Resolution A 960(23) lacks guidelines regarding hours of work and hours of rest. Unlike seafarers who adhere to the Maritime Labour Convention, 2006 (ILO, 2006) and the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended (STCW) (IMO, 2017). Maritime pilots are not subject to such working hours provisions. This exemption, coupled with the absence of specific regulations, has led to issues highlighted by Uğurlu et al. (2017) concerning working conditions and safety concerns among pilots. Commercial pressures undermine pilotage organisations' ability to make independent safety-related decisions, leading to stress and reduced job performance. Irregular work schedules and on-call periods disrupt sleep patterns, potentially resulting in fatigue and cognitive impairments.

Furthermore, regarding medical fitness and physical capability, IMO Resolution A 960(23) refers to medical fitness standards aligning with standards required for the certification of masters and officers in charge of a navigational watch under the STCW. However, the STCW and IMO Resolution A 960(23) standards lack requirements addressing the physical strain of boarding pilot ladders. Neglecting pilots' physical condition can lead to fatigue and increased accident risks. The absence of psychological assessments is another shortcoming, considering the profession's irregular hours and psychological strain (Oldenburg et al., 2020).

Accident and near-miss reporting and their relevant investigation procedures are also inadequate. While IMO resolution A 960(23) mandates reporting navigation-related hazards, they do not cover accidents or near-misses involving pilot transfer arrangements.

Lastly, the IMO resolution A 960(23) did not provide technical specifications for pilot boats to ensure safe transfers in adverse weather conditions or guidelines for postponing transfers in adverse weather conditions. This absence of technical specifications presents challenges for safe pilot transfers under adverse weather conditions.

2.3.3 International safety management (ISM) code standards

The ISM Code has been a regulatory foundation to foster a safety-oriented culture within shipping companies by establishing effective Safety Management Systems (SMS). This implementation has shown positive outcomes in terms of enhancing safety culture awareness in the maritime industry, as evidenced by Jung's (2021) research findings. Nevertheless, it is essential to acknowledge that the SMS within numerous shipping companies has been criticised for its rule-oriented nature, leading to increased bureaucracy and broad-based implementation, as noted in the study by Teperi et al. (2019). Additionally, the organisational culture within shipping companies is not always homogeneous and cohesive; the coexistence of multiple safety levels within a single company is likely unavoidable (Berg, 2013). Considering the global nature of stakeholders involved in pilot transfer operations, various safety priorities and commitments may be evident within these subcultures, which can potentially influence safety practices and outcomes.

Amongst the role of human factors on the ship, it was found that the primary reason for these accidents was the use of faulty or non-compliant ladders or gangways. According to Aydin et al. (2022), the main factors for pilot transfer arrangement accidents can be eliminated by properly applying the ISM Code and enhancing the safety culture onboard. Uflaz et al. (2023) conclude that adhering to the checklists outlined in the ISM Code will significantly strengthen the pilot transfer arrangements' safety and reduce the accident rate.

In addition, pilot transfer arrangements are considered part of the safety equipment on board ships and must be inspected regularly before every use (Vukić et al., 2021). For the inspection of pilot transfer arrangements, it is crucial that it is inspected using standardised criteria, following consistent and specialised training. The lack of inspection harmonisation mainly contributes to the deterioration of pilot transfer arrangements (Grbić et al., 2018).

According to Hasanspahić et al. (2022), the analysis of reported cases concerning pilot transfer arrangements reveals that all corrective actions focused solely on addressing the immediate cause of the near miss rather than investigating the root cause. For instance, a specific report involving a pilot ladder with a bent rubber step was subjected to corrective action, which included repairing the step and fixing the ladders. Additionally, new pilot ladders were requisitioned, but the investigation into the reason behind the bending of the rubber step was not pursued. Another near-miss report highlighted falls from height during pilot boarding, wherein one pilot was left unattended due to the unawareness of the ship's crew. The immediate corrective action, in this case, involved advising the captain from the bridge about the presence of the second pilot on the gangway. However, it is evident that a procedural flaw existed, as the bridge team was unaware that two pilots were boarding the ship, and the root cause of this issue remained unaddressed. The Designated Person Ashore (DPA) reacted and revised the procedure for pilot boarding. The failure to address the root cause may result in the absence of appropriate safeguards, leading to the potential recurrence of near-miss incidents or their escalation into more serious accidents.

It is the company's responsibility to ensure that the SMS is adequately covering the inspection, maintenance, and verification of design compliance of the pilot transfer arrangements. The ship's crew is trained to ensure the pilot transfer arrangements are appropriately maintained, inspected, and rigged as part of the SMS under the ISM code certification. Compliance with these regulations is critical to the safe and efficient operation of the ship and the protection of the lives of crew members and pilots.

2.3.4 Analyzing the newly proposed amendments related to pilot transfer arrangements regulations

There is an ongoing discussion to amend the IMO regulations governing the Pilot transfer arrangements. A proposal was submitted during the 10th session of the Sub-Committee on Navigation, Communications, and Search and Rescue on February 7, 2023, Proposing amendments to SOLAS Regulation V/23 and Resolution A.1045(27) (IMO, 2023b).

The proposed amendments are slated for implementation concerning pilot transfer arrangements on or after January 1, 2028. For arrangements installed prior to this date, compliance with the regulations is required no later than the first survey after January 1, 2028. However, considering the heightened occurrence of accidents involving pilot transfer arrangements leading to serious injuries and fatalities, there's a compelling need for earlier implementation to safeguard users' lives.

The new amendments introduce a notable change by stipulating that a responsible officer should supervise pilot embarkation and disembarkation. However, the duties of the responsible officer have not been mentioned in the amendments. Additionally, it obviates the requirement for an additional deckhand at the station. Underestimating the indispensable role of deckhands in ensuring operational safety, warranting their presence alongside the pilot and the responsible officer during transfer operations.

The importance of training personnel engaged in inspecting, maintaining, rigging, or operating pilot transfer arrangements is highlighted. However, there is a lack of clarity within this context regarding the frequency of such training and the entity responsible for providing it. Additionally, the regulation addressing lighting has persisted without revision despite the occurrence of accidents during nighttime operations.

The aspect of operational readiness, onboard inspection, and maintenance has garnered attention. A proposed inspection schedule every three months seeks to elevate ladder safety and mitigate accidents stemming from insufficient maintenance practices. This proactive approach can significantly contribute to the safety and reliability of pilot transfer operations.

Turning to Resolution A.1045(27), a significant change involves shifting from recommendations to performance standards, which will then be a binding instrument through enacting it in SOLAS regulations.

Notably, the amendment emphasises the preferred method of clamping steps, disallowing the use of cable ties, u-clamps, worm-driven clips, or any other material that could degrade the ropes. The amendment will reduce the degradation of ropes and mitigate the risks associated with parting of the side ropes.

Furthermore, the proposed amendments address the physical positioning of pilot ladder winch reels, particularly for long pilot ladders. However, it fails to outline methods for fixing intermediate lengths, leaving room for ambiguity. Additionally, the prohibition of using shackles and ladder steps or spreaders for fixing purposes should be explicitly incorporated to prevent conflicts among officers responsible for securing pilot ladders. It also did not mention the rolling hitch knot as a preferred safe way to secure the ladder at intermediate lengths, as discussed by Symonds et al. (2023) in their study.

Despite the importance of fixing the ladder at the ship's side, as mentioned by the study conducted by Murai et al. (2012), which showed that the pilots' acceleration increased when disembarking the part of the ladder that is not fixed to the side which may result in falling.

In conclusion, the 10th session of the Sub-Committee on Navigation, Communications, and Search and Rescue marked a crucial milestone in maritime safety through proposed amendments to SOLAS Regulation V/23 and Resolution A.1045(27). These amendments signify the maritime community's unwavering commitment to bolstering safety measures for pilot transfer arrangements. While the amendments represent commendable progress, opportunities remain for enhancing language precision, clarifying training procedures, and addressing oversights in specific regulations to fortify pilot transfer arrangemets safety standards further.

2.4 International organisations for standardisations

Moving out from the IMO regulations, there are two distinct standards established by separate entities: ISO and the ISPO International Users Group (IUG). ISO sets the criteria for pilot transfer arrangements and associated equipment. Conversely, ISPO focuses on standardising the pilot organisations' protocols, procedures, and organisational standards.

2.4.1 ISO standards supplementary guidance

The ISO has established the ISO 799 series, as shown in Table 1, which encompasses standards related to pilot transfer arrangements. This series covers various aspects, starting from design considerations and extending to maintenance, usage, surveys, inspections, and the formulation of standards for attachments and related equipment. The primary objective of the ISO 799 series is to complement the existing IMO regulations pertaining to pilot transfer arrangements. The ISO standards aim to address the gaps present in the IMO requirements related to pilot transfer arrangements regulations (ISO, 2019, 2021, 2022).

Table 1 ISO 799 series Ships and marine technology — Pilot ladders

ISO 799-1:2019	guidelines covering the pilot transfer arrangements design and specification
ISO 799-2:2021	guidelines covering the maintenance, use, survey, and inspection of pilot transfer arrangements
ISO 799-3:2022	guidelines covering the attachments and associated equipment

ISO 799-1:2019 focuses on testing pilot transfer arrangements and highlights the absence of specific requirements for prototype testing in the IMO instruments (ISO, 2019). Notably, SOLAS Chapter V Regulation 23.2.3 references the ISO standard (ISO 799-1), officially recognising it as a guideline for testing and certifying pilot transfer arrangements.

ISO 799-2:2021 addresses the need for specific IMO requirements regarding manufacturers' guidance on the maintenance, storage, and use of pilot transfer arrangements (ISO, 2021). While IMO regulations specify design and construction requirements for pilot transfer arrangements, they lack detailed instructions for ensuring effective maintenance, storage, and use throughout the equipment's lifespan.

ISO 799-3:2022 deals with pilot transfer arrangements attachments and associated equipment, which are essential for safe pilot embarkation and disembarkation from ships (ISO, 2022). Existing IMO requirements do not provide adequate clarity or details on specific aspects of these attachments and associated equipment.

It's noteworthy that both SOLAS and IMO Resolution A.1045 (27) mandate the certification of pilot ladders by the manufacturer according to ISO 799-1:2019. However, ISO 799-2:2021 and ISO 799-3:2022 are not currently mandated by any of the IMO regulations.

2.4.2 International standard for maritime pilot organisations

A significant number of accidents related to pilot transfer arrangements can be attributed to deficiencies in these arrangements and a lack of robust safety cultures aboard vessels. Often, these issues stem from a disregard for onboard safety management systems (Aydin et al., 2022; Camliyurt et al., 2022; Uflaz et al., 2023). However, an additional set of factors contributing to these accidents can be attributed to the pilot organisations themselves (Abreu et al., 2022; Tunçel et al., 2022).

Unlike adhering to international regulations, pilot organisations are governed by local regulations (Jia et al., 2020). However, the ISPO was established by the IUG of ISPO-certified organisations to act as an advisory body for pilotage organisations (ISPO, 2023a). The ISPO-IUG introduced the Standards Code and the Control Manual (ISPO, 2021a, 2021b), which are very similar to what has been promulgated in the IMO Resolution A 960(23).

It is noteworthy that compliance with the ISPO-IUG standards remains limited, with only 32 organisations and approximately 1350 pilots adhering to them (ISPO, 2023b). This low adoption rate, as explained by (Kunnaala et al., 2013), reflects concerns that ISPO may clash with the principle of regulated, non-competitive pilotage upheld by independent professionals for safer navigation.

2.5 Non-governmental organisations' contributions to pilots' safety

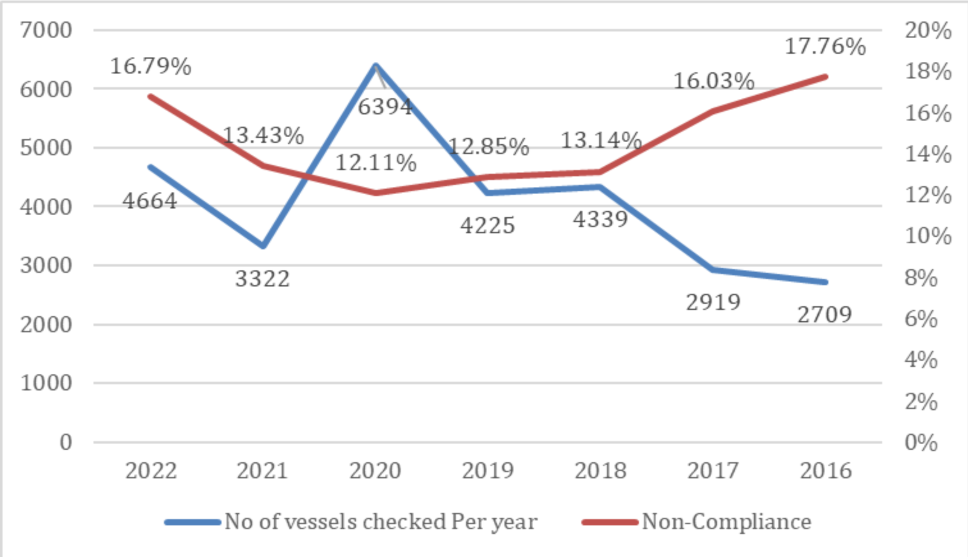
2.5.1 International maritime pilots' association (IMPA)

Pilots' organisations worldwide have united to establish associations aimed at fostering solidarity and offering support to diverse pilotage authorities. The IMPA is one of the largest global pilots' associations, formed in June 1970; currently, it represents over 8200 pilots from 53 countries. IMPA's main objective is to promote professionalism and safety in the pilotage operation. IMPA is also an accredited consultative member of the IMO since 1973. It participates in the committees, sub-committees, and the IMO working groups as a non-governmental organisation (IMO, 2023a; IMPA, 2023).

Despite the longstanding relationship between the IMPA and the IMO, there has been a notable disparity in their participation in IMO working documents. From March 1999 to April 2023, the IMPA took part in 53 working documents, of which only 29 originated from the IMPA. Among these documents, 14 were explicitly related to the safety of transfer arrangements (IMO, 2023c).

The IMPA has undertaken seven pilot transfer arrangement surveys within the past 15 years, with a notable shift towards conducting them annually since (IMPA 2016, 2017, 2018, 2019, 2020, 2021, 2022), as indicated in Figure 5.

Figure 5 Number of pilot transfer arrangements checked and percentage of non-compliant arrangements.

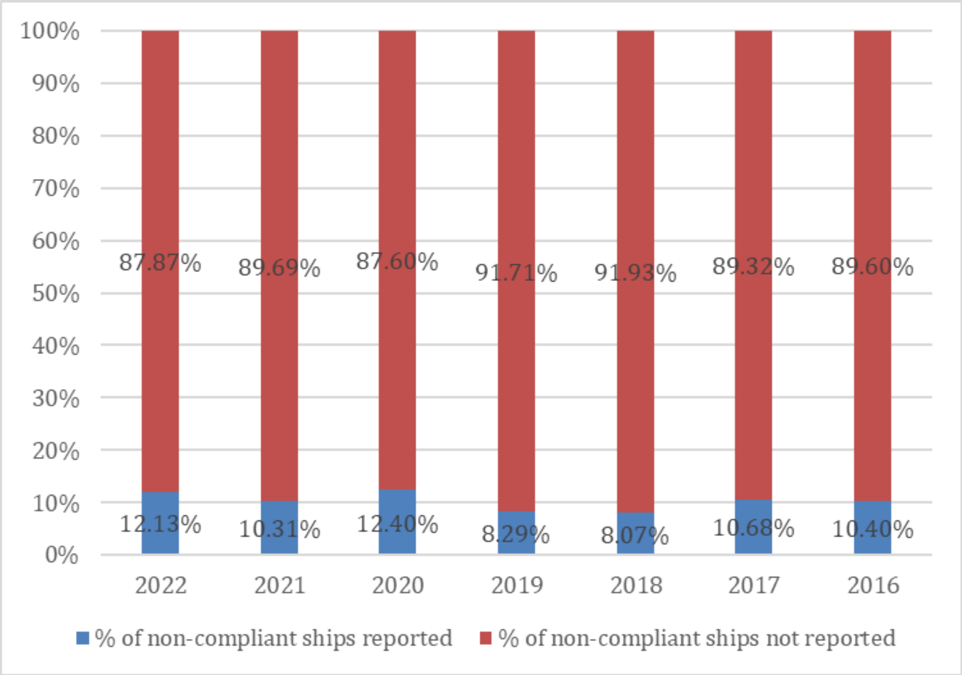


Note. Data collected by the author from IMPA surveys reports 2016-2022.

Based on the data collected from the past seven years survey reports, an average of 4,082 vessels were assessed annually. The results revealed an average non-compliance rate of 14.6%. Applying this ratio to the current worldwide SOLAS vessels fleet, which stands at approximately 65,400 vessels according to Clarkson's World Fleet Register (Clarksons, 2023). It is estimated that there are currently around 9,550 vessels with non-compliant pilot transfer arrangements, consequently posing significant risks to pilots using them.

Additionally, upon a thorough analysis of the IMPA reports, it was observed that roughly 90% of non-compliant pilot transfer arrangements go unreported. In comparison, only 10% are brought to port state control officers and authorities, as illustrated in Figure 6. This implies that an additional ninety unreported instances of non-compliant pilot transfer arrangements exist for every ten defects reported, significantly heightening the risks associated with pilot transfer arrangement accidents.

Figure 6 Rate of reporting of non-compliance pilot transfer arrangements to the authorities



These findings raise important questions about the effectiveness of the current reporting approach for non-compliant pilot transfer arrangements and call for a critical examination of the factors contributing to the persistently high number of non-compliant ladders and accidents.

Additionally, the IMPA has issued the Pilot Boarding Arrangements Poster to illustrate the requisite boarding arrangements for maritime pilots (IMPA, 2012). However, it is imperative to note that the poster has exhibited certain discrepancies compared to established regulations (Palmers, 2020). These inconsistencies raise concerns regarding the effectiveness and safety implications of the boarding arrangements depicted. Consequently, they risk misinforming or inadequately pilot transfer arrangements, potentially leading to operational inefficiencies and, more critically, compromising safety.

2.5.2 International chamber of shipping (ICS)

The ICS has issued the "Shipping Industry Guidance on Pilot Transfer Arrangements" in collaboration with IMPA (ICS & IMPA, 2022). However, upon reviewing the guidance, it becomes evident that it offers only brief and provide general advice regarding ensuring safe rigging for pilots, management responsibilities, and on-board responsibilities. This level of detail does not adequately address the safety requirements of pilot transfer arrangements.

2.6 Development of pilot transfer arrangements design

This study focuses on the safety pilot transfer arrangements, which have remained largely unchanged for the past three centuries (Hignett, 2012). Despite issues surrounding pilot transfer arrangements and associated equipment contributing to numerous accidents (Hall et al., 2017), these arrangements have persisted in their primary design and materials.

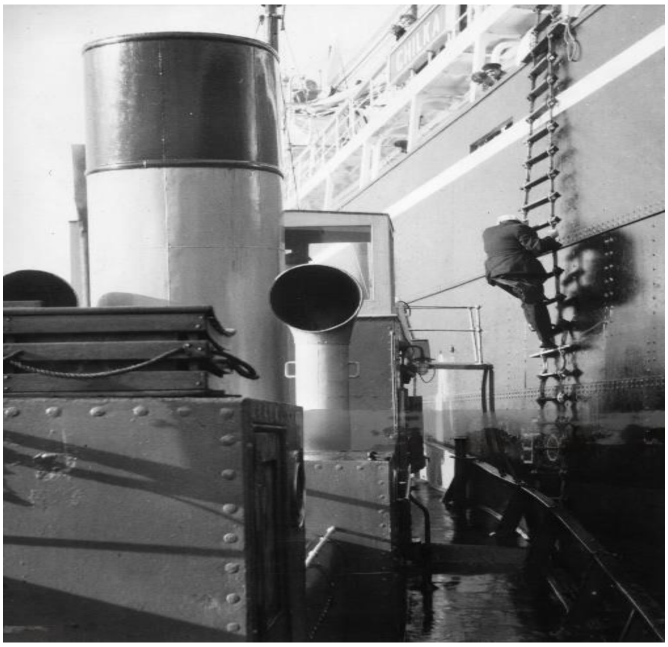
The concept of "grandfathering" plays a significant role in shaping human factors, especially within the maritime culture context. In cultures that adhere to grandfathering practices, knowledge and information are transmitted from one generation to the next, creating an environment that may resist change and innovation due to deeply ingrained and upheld traditional methods and beliefs (Ferrarello et al., 2017).

The three photos below illustrate pilots boarding vessels to provide pilotage services over three centuries. Figure 7, dating back to 1883, depicts a pilot boarding a sailing ship (Hans Hogman History, 2023). Moving forward 50 years, Figure 8, taken in 1930, shows a river pilot from the PLA Pilot station at Gravesend, Kent, climbing up to pilot the ship to its destination at London docks (Getty Images, 2023). Finally, Figure 9 captured in 2020, illustrates a pilot boarding a container vessel (Amy, 2020). These images reveal significant transformations in vessel construction, pilot boat designs, and even the inclusion of female pilots in modern times.

Figure 7 Pilot boarding a sailing ship, 1883

Note. Published in the Swedish newspaper "Ny Illustrerad Tidning."
Source: https://www.hhogman.se/maritime-piloting-swe.htm

Figure 8 River pilot at Gravesend, Kent 1930



Source: Getty images - https://www.gettyimages.ae/detail/news-photo/river-pilot-from-the-pla-pilot-station-at-gravesend-kent-news-photo/3402714

Despite advancements brought forth by the industrial and technological eras, it is noteworthy that pilot ladders' primary design and materials have remained largely unchanged over these centuries. This observation underscores the importance of critically examining and addressing safety concerns associated with current pilot transfer arrangement designs.

Figure 9 Female pilot boarding a large container vessel in 2020.

Source: https://outchasingstars.com/harbor-pilot-for-the-day-in-suape/

The design challenge at hand involves a comprehensive examination of the entire boarding process, considering all physical and psychological factors that may impact the activity, as well as the operating and storage conditions and the stresses under which ladders are imposed. Designers must grapple with the industry's historical tendency towards low investment and a reluctance to adopt innovations (Ferrarello et al., 2017; Hall et al., 2017). Enhancing the designs of pilot transfer arrangements appears to be an initial and logical step to address safety concerns. This reluctance is evidenced by the gradual and cautious progress observed in modifying both equipment and procedures over time (Kann et al., 2017).

In 2017, the Royal College of Art and Lloyd's Register Foundation jointly released a report titled "Safeguard Challenge," focusing on addressing safety concerns related to shipboarding, particularly pilot transfer arrangements. The report proposed new designs and safer materials for pilot ladders with the intention of overcoming existing safety issues. Adopting modern materials and advanced technologies in pilot transfer arrangement construction could significantly enhance safety standards (Kann et al., 2017). However, despite promising recommendations and proposed innovations, limited progress has been made in implementing these changes. The industry continues to rely on traditional pilot ladders, and there appears to be a reluctance to embrace the suggested designs and materials.

2.6.1 Pilot transfer arrangements securing systems

One of the primary challenges during pilot boarding is the swing of the ladder away from the ship's side, especially when the ship is rolling (Ernstsen et al., 2018). Recently, there have been developments in clamping devices designed to address this issue by securely fixing the pilot ladder during boarding and disembarkation. The devices use magnets to affix the ladder to the ship's side or are based on vacuum theory (PTR Holland, 2023a, 2023b). Despite the approval from various classification societies, it is noteworthy that SOLAS has not included the requirements for such clamping devices in its regulations or recommendations. Furthermore, the pilots' associations have not actively urged the IMO to adopt these devices to enhance pilot safety and reduce accidents. However, the Australian Maritime Safety Authority (2023) has taken a proactive stance in its notice Pilot Transfer Arrangements, which now require both the pilot and the combination ladder to be fixed to the ship's hull using a magnet clamping device.

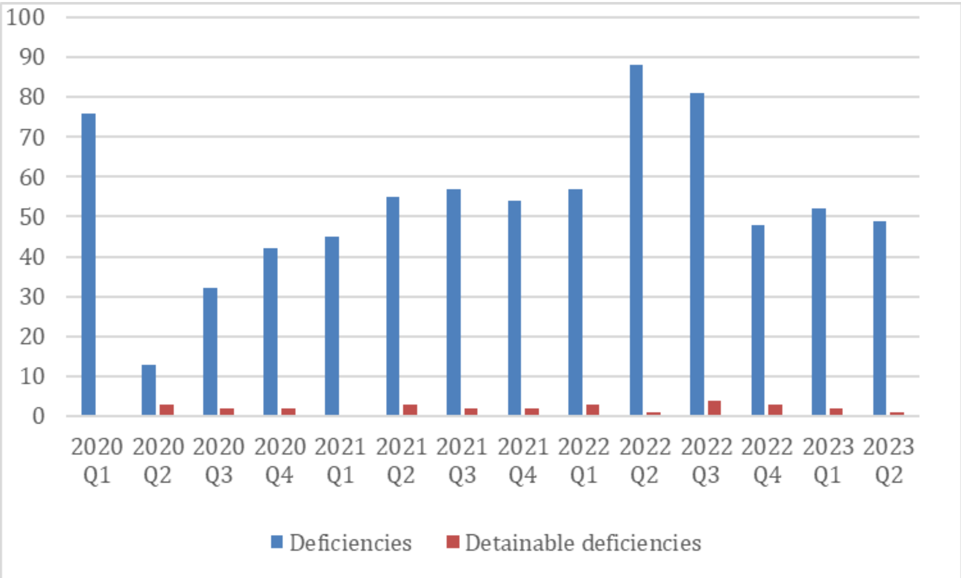
Notably, no academic research was conducted to explore the benefits and limitations of using clamping devices and their potential role in reducing the number of accidents during pilot transfers. Such studies could significantly contribute to understanding the effectiveness and impact of these devices on pilot safety.

2.7 External parties' inspections and verification of compliance

It is globally acknowledged in the maritime industry that port state control (PSC) serves as the second defence line after the flag state inspections and verification of compliance (Yan & Wang, 2019). It is important to note that PSC and flag state control are viewed as complementary approaches. The primary aim of PSC inspection is to validate whether the ship's condition and equipment conform to the standards set by international regulations (Akyuz et al., 2016).

Upon conducting a comprehensive analysis of the Paris MoU (2023) database covering January 2020 to June 2023, PSC officers identified 749 deficiencies, of which 28 were deemed detainable, as shown in Figure 10. The graph clearly illustrates that the number of deficiencies has remained relatively high over time.

Figure 10 Paris MoU deficiencies related to pilot transfer arrangements.



Note. Pilot transfer arrangements deficiencies obtained from Paris MoU database.
Source: https://parismou.org/Statistics%26Current-Lists/inspection-results-deficiencies

This alarming trend necessitates increased attention and more stringent inspection measures to ensure adherence to the pilot transfer arrangements. Taking prompt action in this regard is imperative to enhance safety and compliance within the maritime industry. Notably, only the Paris MoU database of the nine PSC MoUs provides detailed statistics on the deficiencies found during inspections.

Upon reviewing the port state controls concentrated inspection campaigns (CIC), Riyadh MoU launched pilot transfer arrangements CIC from September 1, 2016, till November 30, 2016. Additionally, the Caribbean MoU had started pilot transfer arrangements CIC on September 1, 2023 (Class NK, 2023). Placing the pilot transfer arrangements on the CIC agendas will enhance the vessels' implementation of the current regulations (Cariou & Wolff, 2015; Lai et al., 2023).

The Bahamas Maritime Authority is also the only flag state that conducted CIC related to pilot transfer arrangements onboard the Bahamian flag from July 1, 2021, to December 31, 2021. The primary observations identified were primarily associated with using substandard and altered pilot and combination ladders, unauthorised alterations to deck access, malfunctioning winches and reels, and improper securing of pilot transfer arrangements. A total of 258 inspections resulted in 103 deficiencies, representing a deficiency rate of 39.9% (Bahamas Maritime Authority, 2022).

2.8 Exploring factors influencing safety in maritime pilot transfer arrangements: A comprehensive literature review

Pilot transfer operations in the maritime setting come with many difficulties that need careful investigation to ensure the safety of the transfer operations as it is affected by various factors. This thorough review of existing research investigates various factors that influence the safety of pilot transfer arrangements. By studying different studies on different aspects, this review aims to understand the many different parts of pilot transfer operation and introduce the different gaps in the studies to ensure safe transfer operations.

2.8.1 Human erroneous actions and safety culture

Human factors exert a substantial influence on pilot transfer accidents. The use of faulty or non-compliant pilot transfer arrangements emerges as a prime cause. Nonadherence to procedures, instructions, and regulations surfaces as another significant contributor, alongside crew negligence influenced by a safety culture and duration of stay onboard (Camliyurt et al., 2022).

A recent study (Aydin et al., 2022) of pilot transfer arrangement accidents analysed the contributing factors to accidents during pilot transfer arrangements using the HFACS. They identified three main causes of pilot transfer arrangement accidents. Firstly, it was observed that accidents occurred when the combination ladder was not fixed along the ship's side and the rope ladder was not rigged properly above the combination ladder. Secondly, accidents were caused by a shortage of crew members available to prepare the ladder. Finally, the absence of a responsible officer at the transfer area to meet the pilot was also identified as a contributing factor to pilot transfer arrangements accidents. However, the three factors' root cause analysis has not been done. The study also did not mention the total human error contribution to the pilot transfer arrangements accidents.

According to Uflaz et al. (2023), in the human reliability analysis under a fuzzy logic environment for ship navigation, the task associated with pilot transfer arrangements represents a crucial sub-task that experiences a notable escalation in human error probability (HEP). This heightened HEP is predominantly attributed to two key factors: a suboptimal working environment and physical limitations. The research concluded that in order to address and mitigate human errors, it is imperative to maintain a clean and organised working environment, particularly on the deck where the pilot transfer arrangements and equipment are positioned.

Camliyurt et al. (2022) conducted a risk assessment for marine pilots' occupational accidents using fault tree and event tree analysis. They analysed the role of human factors and found that the primary reason for these accidents was the use of faulty or non-compliant ladders or gangways. The second most significant cause was the failure to adhere to procedures, instructions, and regulations. Negligence of the ship's crew, which is influenced by the safety culture and duration of their stay on board, was identified as the third contributing factor.

These studies highlight the interconnectedness of safety protocols, human performance, and organisational safety culture in preventing pilot transfer accidents. They advocate for a multifaceted approach encompassing proper ladder arrangement accidents, adherence to regulations, enhancement of safety culture, and steadfast application of ISM principles to ensure the safeguarding of maritime operations and personnel. The studies focused on the human role in the pilot transfer arrangements without investigating the other elements engaged in the pilot transfer operation process and the interaction between these elements.

2.8.2 Lack of pilot transfer arrangements maintenance and inspection

Addressing the implications of inadequate maintenance, Tunçel et al. (2022) and Broers (2021) emphasise the undeniable impact of the lack of maintenance and replacement regulations on the frequency of pilot ladder and accommodation ladder-related incidents and underscores the significance of regulatory documentation to ensure secure and proficient ladder rigging, use, maintenance, and handling.

Pilot transfer arrangements accidents have been subject to study, revealing that a notable fraction of incidents involving pilot transfer arrangements can be attributed to deficient maintenance 21% and negligent rigging 33%. Furthermore, a considerable proportion of respondents, 49%, attribute failures to lack of maintenance and proper storage, while 41% point to wear and tear coupled with crew reluctance to replace ladders. A notable observation is the perception among 10% of respondents that casualties result from shipowners' failure to procure new ladders (Behforouzi, 2021).

Furthermore, the role of pilot transfer arrangements as integral shipboard safety equipment necessitates their meticulous inspection before every use and regularly (Vukić et al., 2021). To ensure consistency, Grbić et al. (2018) underscore the importance of standardised criteria and consistent, specialised training for pilot transfer arrangements inspections. The absence of harmonised inspection practices is identified as a primary contributor to the degradation of pilot transfer arrangements conditions. Establishing a systematic maintenance framework, coupled with effective international safety management practices, emerges as indispensable. Regular inspection of pilot transfer arrangements, coupled with prompt rectification of deficiencies, emerges as a linchpin for operational safety (Grbić et al., 2018; Vukić et al., 2021).

2.8.3 Physical demands, fatigue, and health factors of pilots

Pilot transfer operations exert enormous physical stress on the pilots and require specific physical abilities for boarding and disembarking the vessels under varying weather conditions, which emerges as a physically demanding task (Kitamura et al., 2014; Okazaki et al., 2010).

While a lack of studies exists regarding pilots' ladder-climbing proficiency, the occurrence of accidents indicates the physical strain associated with such climbs. Fatigue, age, physical ability, and body mass index (BMI) are critical factors influencing pilots' safe climbing capability (Rutledge, 2014). Main & Chambers (2015) highlight the scarcity of research concerning pilots' health, revealing alarming statistics that between 53% and 64% of pilots are classified as overweight or obese. A study conducted by Oldenburg et al. (2021) further underscores this trend, reporting that 72.8% of surveyed pilots fall into the overweight or obese category. Furthermore, empirical evidence points to reduced boarding/disembarking speed with ladders exceeding 4 meters, potentially attributable to physical stress (Sugihara et al., 2013). The findings accentuate the growing prevalence of overweight pilots and raise concerns about the adequacy of existing regulations to address evolving challenges regarding pilots' physical ability within pilot transfer operations.

A study involving 19 pilots (aged 36-56 yrs.) found that over 80% were overweight, potentially elevating accident risks due to increased body weight. Moreover, 42% displayed weak maximum oxygen consumption capacity, with 53% exhibiting below-average capacity. These findings underscore the necessity for comprehensive evaluation, monitoring, and enhancement of the overall physical conditioning of pilots and trainees. The implementation of tailored physical training regimens could serve as a preventive measure against accidents and injuries (Günay, 2016).

Pilots' physical and physiological state is paramount during transfer operations (Günay, 2016). Insufficient medical and physical assessments can culminate in physical fatigue, heightening accident risks (Rhodes & Gil, 2002; Weigall, 2006). Disruption of circadian rhythms due to irregular shift start times leads to unpredictable sleep patterns, exemplified in studies by Flynn-Evans et al. (2018) and Murray et al. (2019). Notably, the absence of psychological assessments in medical examinations coupled with the profession's demands for extended and irregular work hours generates substantial psychological and physical strain. The lack of standard regulations governing work hours and the prevalence of night operations further aggravate this strain (Oldenburg et al., 2020).

Uğurlu et al. (2017) conducted a study on the working conditions of pilots, revealing significant challenges within the examined sample. These challenges stem from commercial and political pressures imposed on pilotage organisations, impeding independent decision-making in boarding refusal for safety reasons. Additionally, there exists no limit on the number of vessels a pilot can handle within a 24-hour period, a determination solely within the purview of pilotage organisations. These factors collectively contribute to heightened stress levels among pilots, hindering their autonomy and performance due to job security apprehension.

Pilots' age emerges as a salient factor in the study of pilot transfer accidents despite the absence of specific regulations or guidelines setting an age limit (Park et al., 2019). Research in this context by Park et al. (2019) in Korea demonstrated an increased accident rate among pilots over 65 years, influencing authorities to reject service extensions for pilots in that age range. A study by Sugihara et al. (2013) established a correlation between pilot age and boarding/disembarking speed, revealing that older pilots exhibited slower speeds on the ladder, hinting at the significance of age-related factors in pilot transfer operations. However, Meere et al. (2005) found no discernible connection between age/BMI and pilot accidents based on the responses to their questionnaire.

The research has indicated an elevated susceptibility of pilots to various diseases compared to the general land-based population. Numerous cases have reported cardiovascular diseases, psychological issues, and accidents among pilots, potentially attributed to irregular work schedules, particularly on-call shifts, that disrupt sleep patterns and lead to fatigue, cognitive impairment, and emotional disorders (Gregory et al., 2020).

In conclusion, the literature review on pilot transfer arrangements underscores the importance of conducting a comprehensive study that delves into all aspects of these operations. The study should identify the deficiencies and gaps contributing to pilot transfer arrangements accidents. To fulfil its intended purpose effectively, this study must adopt a holistic approach when assessing the pilot transfer arrangements system. This approach will enable a thorough examination of the system's components and interactions, identifying gaps and implementing necessary improvements to enhance the safety of pilot transfer arrangements.

Chapter 3: Methodology

3.1 Introduction

This chapter aims to introduce the methodology for the research. The pilot transfer operation is a complex socio-technical system that involves various elements, thus, to ensure a safe pilot transfer operation, it is essential to understand how each component interacts with the others. This chapter will conceptualise a socio-technical framework for the pilot transfer system to identify the system's vulnerabilities.

This analysis aims to uncover the underlying causes and interactions between human, organisational, and external factors. By thoroughly examining accident investigation reports and incorporating expert opinions through semi-structured interviews, the author aims to gain a comprehensive understanding of the factors that played a role in these accidents and to develop the framework of the safe pilot transfer operation's complex socio-technical system.

3.2 Research dataset

3.3 Pilot transfer arrangements accident reports

All the pilot transfer arrangement accident investigation reports available in the public domain were collected, regardless of their geographical origins or chronological placement, and incorporated into the study (See Appendix A for the list of accidents reports collected).

3.3.1 Accident investigation reports analysis

This study analysed the accident reports using the IMO Circular “Revised harmonised reporting procedures - Reports required under SOLAS regulations I/21 and XI-1/6, and MARPOL, articles 8 and 12”(IMO, 2014). The Marine Casualty Investigation (MCI) circular is a dynamic and interlinked system to support the submission of in-depth root causes (J.-U. Schröder-Hinrichs et al., 2023).

The accident investigation reports were coded using the MS Excel datasheet. The evaluation of the MCI module in the coding process considered criteria such as the ability to classify accident-causing factors, identification of unclassifiable factors, and detection of overlapping factors that contribute to the accident occurring. The accidents were coded using an Excel datasheet generated in accordance with IMO Circular MSC-MEPC.3/Circ.4/Rev.1, which had been previously utilised in a study presented to the IMO Sub-Committee on Implementation of IMO Instruments titled "Pilot study of passenger ship casualties" (J.-U. Schröder-Hinrichs et al., 2023) after making the required amendments to align with the scope of the study. The coding process underwent meticulous review by two experienced specialists deeply engaged in maritime accident analysis, ensuring unanimity in the adopted coding methodology.

The next step entailed conducting a statistical analysis of the coded accident data using the revised MCI taxonomy. This analysis focuses on various aspects, such as the type of action involved (embarking or disembarking), the contributing factors to the accidents, the physical condition of the casualty, the state of equipment, compliance and maintenance records, the utilisation of personal protective equipment (PPE), and the subsequent actions taken following the incidents.

3.4 Semi-structured interviews

Semi-structured interviews were conducted to cover the gaps in the accident investigation reports, validating the accident analysis results and identifying root cause analysis on the most frequently observed accident-contributing factors.

3.4.1 Data collection and processing

All the interviews were conducted online via Zoom meetings, transcribed and coded via the NVivo Transcription tool. The average time for each interview was 45 minutes.

3.4.2 Ethical considerations

Prior to the interviewees' participation in the study, participants were provided with informed consent as outlined in Richardson & Godfrey (2003) research. They were fully briefed on the study's purpose. Additionally, participants were informed that their participation was voluntary and assured of the confidentiality of the interview and the protection of the information collected. They were also informed that all gathered data would be deleted once the research was completed and the academic degree was awarded. Participants in these interviews were regarded as experts in the field by experience; therefore, when given this opportunity to speak freely, they provided precious information related to the research. The interviews were comprised of both open-ended and direct questions (See a sample of the interview questions in Appendix B).

In accordance with the guidelines established by the World Maritime University, prior to commencing interviews involving human participants, it is imperative to seek approval from the Research Ethics Committee (REC). This approval process entails the submission of a comprehensive application comprising the following components: (1) a well-defined research proposal, (2) the WMU-REC Protocol form, (3) an exemplar consent form encompassing an information sheet, and (4) the semi-structured interview questionnaire. The data collection procedures were initiated only after receiving official approval from the REC.

3.5 Development of a framework to appraise pilot transfer arrangements safety

3.5.1 Maritime accidents model's evolution

The maritime industry and researchers rely significantly on accident investigation reports to gather feedback on maritime incidents (Celik et al., 2010; J. U. Schröder-Hinrichs et al., 2011; Zhang et al., 2019). The accident reports are subjected to meticulous analysis, facilitating the extraction of invaluable insights that are subsequently employed to develop measures to prevent accident recurrence. This feedback mode constitutes a fundamental channel for enhancing overall safety.

Focusing on pilot transfer arrangements accidents, researchers employ various accident analysis techniques, such as Fault Tree Analysis (FTA), Event Tree Analysis (ETA), Failure Mode and Effects Analysis (FMEA), Human Factors Analysis and Classification System (HFACS), Cognitive Reliability and Error Analysis Method (CREAM), Formal Safety Assessment (FSA), and Ethnographic studies. However, the existing accident analysis methods were developed years ago and needed more capabilities in analysing complex and dynamic systems.

Conventional accident models typically view accidents as a sequence of events or a chain of causality, but they have certain limitations. The selection of events for analysis is often subjective, and they fail to consider systemic factors contributing to accidents (Han et al., 2019; Hulme et al., 2019, 2021; Underwood & Waterson, 2013). Moreover, the old models focus solely on specific events leading up to an accident, neglecting the entire process. Accidents are perceived as coincidences of factors resulting in an accident, but this perspective overlooks the broader causal timeline. These techniques primarily concentrate on analysing errors occurring at early stages without exploring comprehensive system weaknesses or underlying reasons for their occurrence (Igene et al., 2022).

In recent years, accident models rooted in systems theory have emerged as a promising approach to address the complexities of ever-changing systems, overcoming the inadequacy of the conventional accident investigation model. The system theory models have evolved from linear to non-linear frameworks (Yousefi & Rodriguez Hernandez, 2019), as they encompass software, hardware, human elements, and their intricate interrelationships (Adhita & Furusho, 2021; Akyuz, 2015; Puisa et al., 2019).

3.5.2 System theory and systematic approach

A system is not static; rather, it is a dynamic process that continuously adapts to achieve its objectives and responds to changes and its environment. For example, a sociotechnical system can be conceptualised as a combination of various systems, including the social system, technical system, and environmental system (Murphy et al., 2014; Niskanen et al., 2016; Siemieniuch & Sinclair, 2014). Understanding the interactions and interrelationships among the system's technical, human, social, and organisational aspects is crucial for comprehending the complexities of modern systems (Borges et al., 2021).

In systems theory, failures are often seen as limitations on the range of permissible behaviours allowed for the interactions among the elements of the system. They represent the acceptable ways through which the system ensures the accomplishment of its desired goals (Leveson, 2011). Safeguards are put in place to restrict the system's behaviour within safe boundaries (Grant et al., 2018; Leveson, 2004). The safeguards include failsafe designs, personnel safety measures, personnel warnings, and self-monitoring (Dreany & Roncace, 2019). The primary objective of a safety control system theory is to enforce safety safeguards and implement the appropriate precautions in the controlled process to avoid accidents or incidents. During the elicitation of safety requirements, safety constraints emerge from identifying the hazards that the safety control system aims to prevent (Han et al., 2019).

3.5.3 System-Theoretic Accident Model and Processes (STAMP)

To address the system approach concept in accident analysis, the STAMP introduced by Leveson offers an approach to accident analysis, focusing on system dynamics and systemic factors as critical contributors to accidents. Although STAMP provides comprehensive and dynamic analysis capabilities, its practical application in the maritime domain still requires further refinement (Leveson, 2016).

By integrating insights from the STAMP model into maritime accident analysis, the research can advance safety measures and gain a deeper understanding of the root causes of accidents in this complex domain. Further research and refinement of the

STAMP approach within maritime contexts can lead to more effective accident prevention strategies and improved safety outcomes.

According to Leveson (2004), accidents in the STAMP model are seen as the consequence of insufficient control over safety-related constraints. Failures in system components or external factors can disrupt the way system elements interact, which may not be adequately controlled by existing safeguards, resulting in accidents or incidents (Leveson, 2009).

Moreover, the STAMP model analyses the relationships and interactions among components and control mechanisms within a system. It views systems as having hierarchical levels of controls and constraints, with each level imposing limitations on the level below it. Information from lower levels about controls and constraints is communicated upwards to inform higher-level controls and constraints. STAMP emphasises the dynamic nature of complex systems, which tend to move towards accidents due to physical, social, and economic pressures rather than experiencing a sudden loss of control capability (Salmon et al., 2012).

3.5.4 Application of system theory to pilot transfer operation

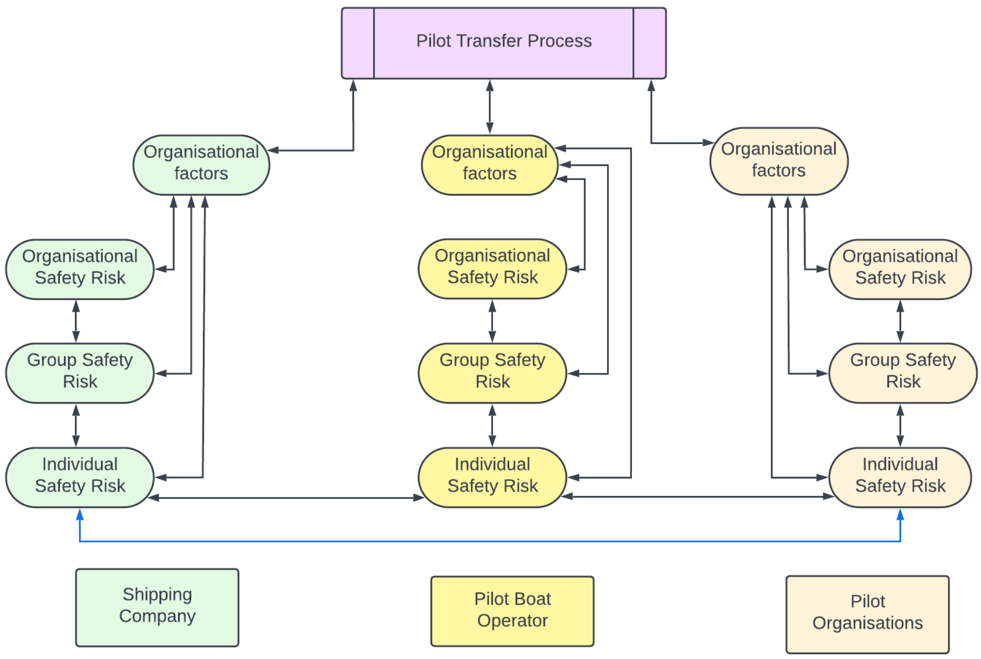
The pilot transfer operation is regarded as a complex socio-technical system comprising various interconnected elements spanning different organisations. These elements encompass human, environmental, technical, and regulatory components, all of which play critical roles in achieving the operation's safety and effectiveness.

The study recognises the imperative of comprehending how these diverse elements interact and influence one another to prevent accidents and enhance existing safeguards. This multifaceted analysis serves as the foundational framework for the research, guiding the assessment of pilot transfer operations' intricacies.

3.5.5 The problem space: Risk management in a dynamic society

Traditionally, the socio-technical system related to risk management is broken down into various organisational levels, each analysed by different disciplines. However, further investigation is needed to explore the vertical interaction among these levels of socio-technical systems, particularly concerning the specific technological hazards they are meant to mitigate (Rasmussen, 1997). The pilot transfer operation is a complex process involving different organisations: the pilot organisation, the shipping company and the pilot boat operator. These organisations are influenced by organisational factors at different levels, as shown in Figure 11.

Figure 11 Organisational factors affecting the pilot transfer operation process.



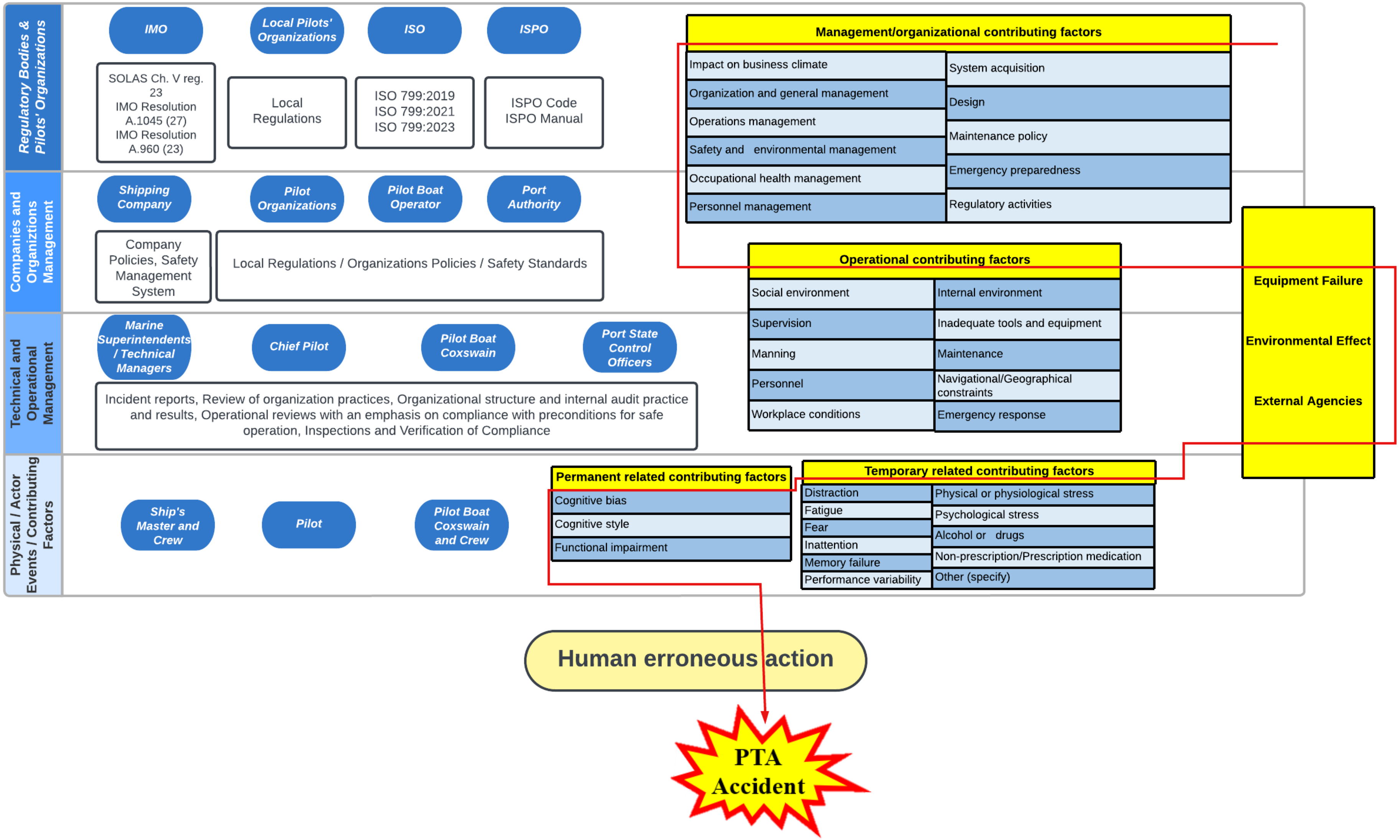
According to Rasmussen (1997), to formulate a risk management framework, the top-level regulators aim to enforce safety through international and local regulations, considering priorities such as safety requirements. The safety control of marine pilot transfer accidents involves multiple levels of individuals in the three organisations, including government authorities, managers, safety officers, vessels' masters, pilots, and pilot boat coxswains. They utilise formal laws, regulations, and instructions to manage hazardous processes and ensure pilot safety during the pilot transfer process. This control system represents a complex socio-technical structure integrating various disciplines at different levels.

3.6 Introduction of the research model: Integration of Rasmussen's risk management framework and IMO MCI circular

Rasmussen's risk management framework, which is rooted in the socio-technical system perspective, primarily centres its attention on human erroneous actions, which are influenced by contributing factors organised in hierarchical tiers.

In the context of the pilot transfer arrangements accidents system approach, this framework is further influenced by external factors such as external agencies, equipment failures, and environmental effects. Therefore, in order to have the full perspective of the pilot transfer arrangements accidents contributing factors, Rasmussen's risk management framework is integrated with the IMO MCI circular, as shown in Figure 12, which provides a conceptual representation of how Rasmussen's framework applies to this study and its integration with the IMO MCI circular.

Figure 12 Author's conceptual representation and integration of Rasmussen's risk management and IMO MCI circular MSC-MEPC.3/Circ.4/Rev.1

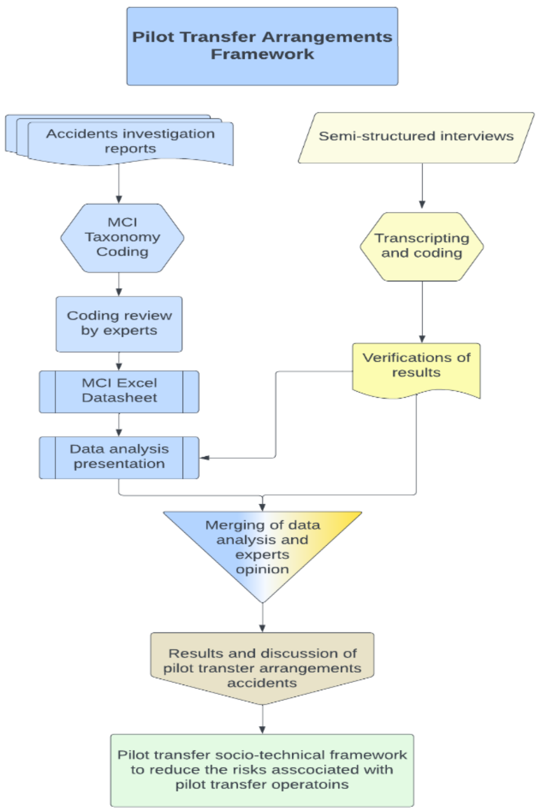


3.7 Pilot transfer arrangements socio-technical framework development strategy

The final stage of this research entails synthesising the findings into a comprehensive framework to implement adequate safety strategies to enhance pilot safety during pilot transfer operations and mitigate future accidents, as outlined in the research objective. To accomplish this objective, a strategy will be employed to amalgamate the results, findings, and trends gleaned from accident reports with the insights gathered from expert interviews, as illustrated in Figure 13.

The primary aim of the researcher is to gain valuable insights into the factors that influence accidents in pilot transfer arrangements. This approach allows the researcher to uncover potential gaps within the socio-technical system of pilot transfer arrangements and identify points of vulnerability. Subsequently, this information can be utilised to formulate a robust safety framework for pilot transfer arrangements.

Figure 13 Pilot transfer arrangements socio-technical framework development strategy



Chapter 4 Results and Discussions

4.1 Introduction

This chapter comprises the presentation of results and subsequent discussion, encompassing accident reports and interview findings. It commences by providing an overview of the dataset demographics and an overview of the accident reports.

The substantive discussions commence in Section 4.3, which is structured in accordance with the integrated framework that aligns with the amalgamation of Rasmussen's risk management principles and the IMO MCI, as illustrated in Figure 12.

4.2 Dataset demographics and overview of the accidents

4.2.1 Semi-structured interviews demographics

The sampling strategy for the maritime experts interviewed in this study, as detailed in Table 2, exhibits a comprehensive approach aimed at gathering insights from various perspectives of personnel engaged with the pilot transfer process. This approach can be justified on several grounds.

Table 2 Interviews participants' data

Interviewee description	Number of participants	Participant's experience in current role (years)
Marine pilot	12	1~15
Master mariner	3	5~10
Chief mate	2	3~4
Officer of the Watch	2	1~4
Pilot boat coxswain	2	10

Firstly, the inclusion of a diverse range of participant roles is a crucial strength of the sampling strategy. Twelve marine pilots were interviewed, -10 males and two females-which provides an in-depth understanding of individuals directly involved in pilot transfers. The varying years of experience among these marine pilots, ranging from 1 to 15 years, ensures that insights from both junior and experienced pilots are incorporated into the study, leading to a more comprehensive perspective.

In addition to marine pilots, the research included three master mariners, two chief mates, two Officers of the Watch, and two pilot boat coxswains. Each of these roles represents a distinct facet of the pilot transfer process. Master mariners contribute their experience as ship captains to the discussion, providing a distinct perspective as they are typically in charge of overseeing the pilot transfer operation. Chief mates play a critical role in ship operation, and their insights can shed light on how pilot transfer arrangements are managed, inspected, and maintained. Officers of the Watch, representing junior officers on board ships, provide fresh perspectives on safety and pilot transfer operations and their roles as responsible officers during the pilot transfer operations according to SOLAS regulations. Meanwhile, two pilot boat coxswains, with ten years of experience each, ensure a thorough understanding of their role in the safety of pilot transfers.

Finally, the geographic distribution of interviewees from different countries is a strategic choice to ensure a diverse background and safety culture. Safety practices and regulations can vary significantly by region, and having international perspectives is crucial for understanding these differences and their impact on pilot transfer safety.

4.2.2 Pilot transfer arrangements accidents demographics

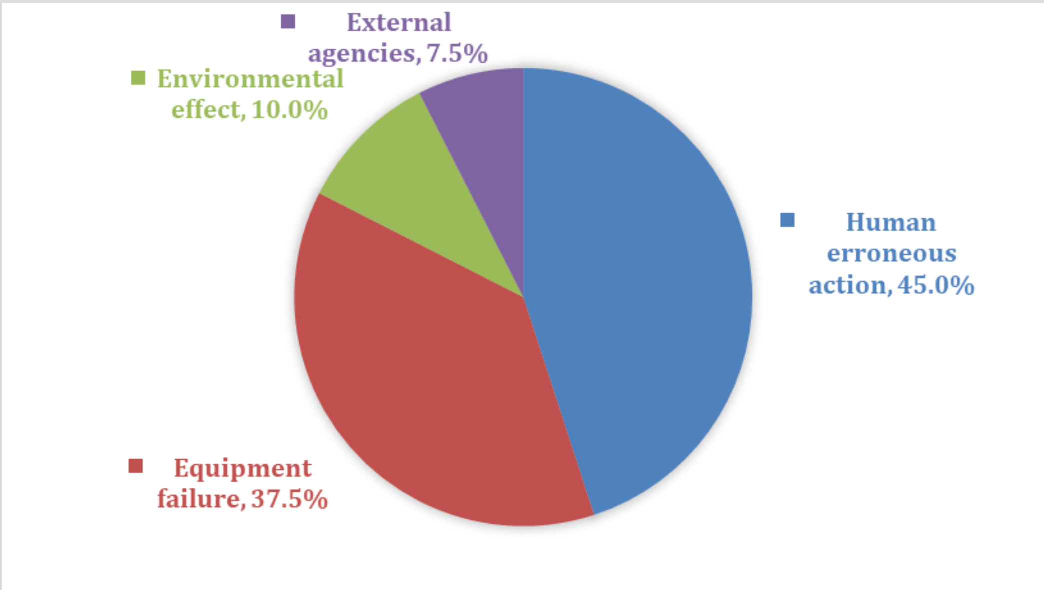
A total of 25 casualty investigation reports spanning the period from 1997 to 2022 were available and acquired from publicly accessible sources, administrative databases, and independent investigative bodies. Additionally, one report on pilot transfer arrangement accidents was retrieved from the Global Integrated Shipping

Information System (GISIS).

4.2.3 Distribution of accident events

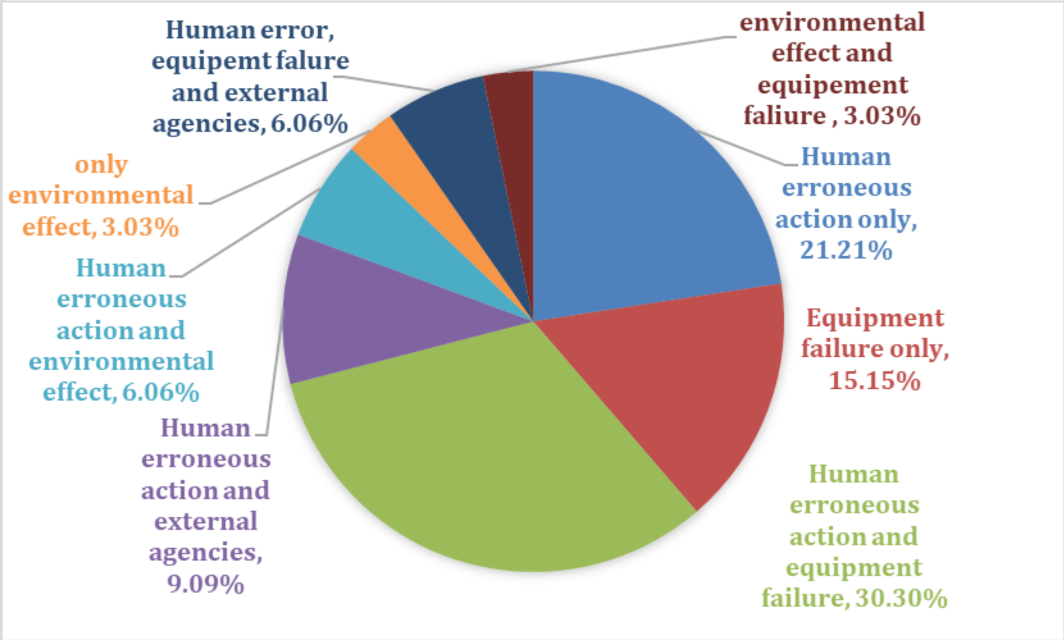
In terms of causal attributions, it is discernible that human erroneous action emerges as the predominant catalyst, contributing to 45% of the aggregate incidents. And the less frequent, external agencies are implicated in 7.5% of the reported incidents, as shown in Figure 14.

Figure 14 Frequency distribution of accident events



Upon reviewing the accident reports, it becomes evident that a diverse range of factors influences the outcomes of these incidents, with each factor playing a unique role of varying significance. Notably, human errors are responsible for 21.21% of incidents, either in isolation or in conjunction with equipment failures 30.30%, external agency involvement 9.09%, or environmental effects 6.06%. Equipment failures independently constitute 15.15% of cases, underscoring their notable impact. Collaborative efforts with external agencies contribute to 9.09% of incidents. Environmental influences, whether solely at 3.03% or combined with equipment failures at 3.03%, are detailed in Figure 15. These findings illuminate the intricate nature of pilot transfer accidents and emphasise the imperative for multifaceted safety enhancements.

Figure 15 Combined distribution of accident events



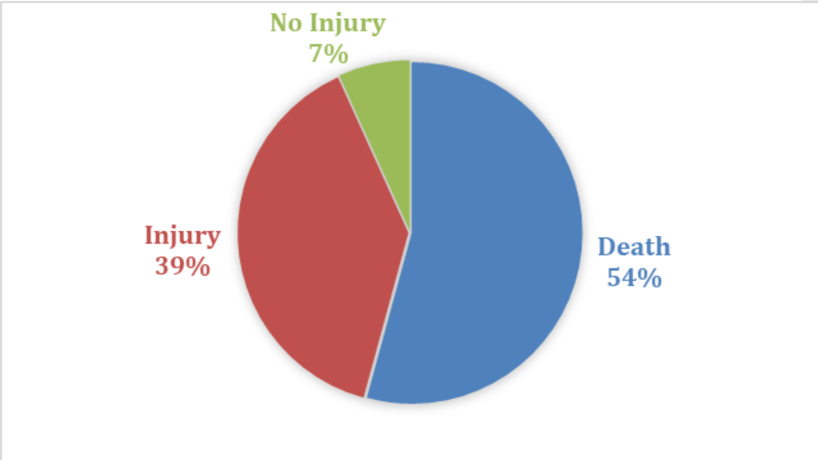
It is widely acknowledged that attributing human error to accidents is influenced by factors within the human factors' framework (Che Ishak et al., 2019; Wróbel, 2021). This viewpoint is extensively discussed in academic literature and holds true for analysing pilot transfer arrangement accidents presented in this research.

The analysis of accidents involving human erroneous actions considers temporary and permanent contributing factors, operational aspects, and management influences, all of which pertain to human involvement, accounting for 45% of the total. Similarly, analysing accidents caused by equipment failure and external factors considers operational and management factors linked to human actions. This interpretation extends to external agencies such as pilot organisations, vessel traffic services, and search and rescue organisations, all involving human activity. The same applies to equipment failures tied to human actions through organisational and managerial elements. While in reality, not all of these incidents can be entirely attributed to human error, hypothetically considering them as such would raise the attribution from 45% to 90%, which means that human error is attributed to 90% of the pilot transfer arrangements accidents which is 10% higher than the frequently cited 80% human error attribution (Wróbel, 2021)

4.2.4 Consequences of casualties

The 25 accident reports revealed a total of 13 injuries and 12 fatalities, accounting for 52% and 48%, respectively. Furthermore, examining the 60 available notices about other accidents indicated that in pilot transfer arrangement accidents, the fatality rate stood at 54%, while the injury rate was 39%. Additionally, it was observed that 7% of the individuals involved in pilot transfer arrangements accidents did not suffer any injuries. An overview is illustrated in Figure 16.

Figure 16 Casualties resulted from pilot transfer arrangements accidents



The injuries identified predominantly stemmed from pilots falling from various heights on the pilot boat. These falls had severe consequences, resulting in fractures, bleeding, and loss of consciousness among the affected individuals.

In terms of fatalities, a closer examination revealed distinct circumstances contributing to the outcomes. Fatalities occurred primarily when pilots fell on the pilot boat or fall into the water after colliding with the pilot boat, rendering them unconscious. Moreover, a considerable number of casualties became trapped between the boat and the vessel, leading to catastrophic consequences. Additionally, pilots might, ultimately resulting in fatal drowning incidents. Notably, out of the 12 fatalities, only three cases involved casualties falling directly into the water, rendering them unrecoverable and leading to unfortunate drownings.

This was explained by Gaillard (2022), who studied the fall on pilot boat surface impact, as shown in Table 3. It also shows the very short period for the duration of the fall, which is not enough for the boat to clear the area and avoid the impact.

Table 3 Consequences of falling on a hard surface

Fall distance	Impact speed	Duration of fall	Physical consequences
3m	28km/h	0.8s	Serious injuries
5m	36km/h	1s	Disability
8m	45km/h	1.2s	Death

According to pilot boat coxswains interviewed, their organisation follows a best practice where the boat remains in position until the pilot has stepped onto the third step of the ladder. Afterwards, the boat clears 5 meters from the ladder, maintaining this distance to ensure that a pilot will not collide with the boat if they fall off the ladder and the boat will be able to provide immediate assistance and facilitate a prompt recovery if the pilot was to fall into the water accidentally.

Furthermore, it has come to light that around 42% of the interviewed pilots provide explicit instructions to the boat coxswain, emphasising the necessity of maintaining a safe distance from the ladder when boarding and disembarking. This precautionary measure serves to avert the risk of pilots inadvertently falling into the water and relying on the buoyancy provided by the lifejackets to remain afloat in case of falling into the water.

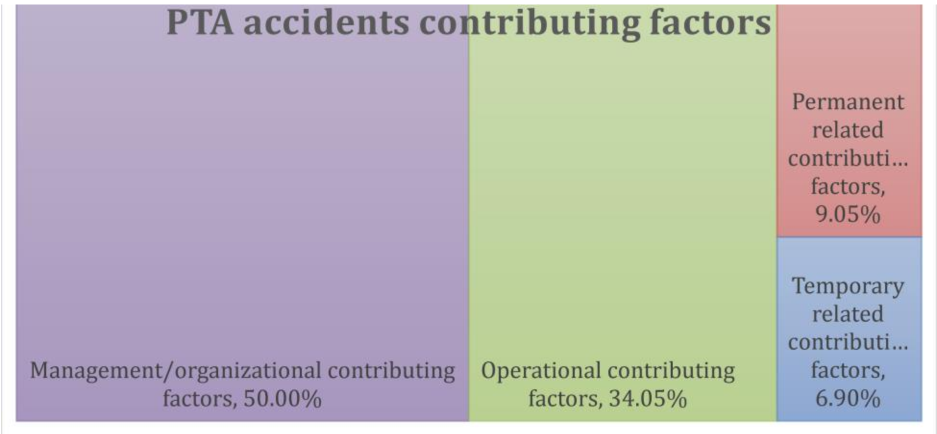
This highlighted practice not only safeguards the well-being of pilots but also serves to preserve the integrity of the ladder itself. The peril of excessive strain resulting from contact with the pilot boat, a significant contributing factor in three analysed accidents, is thereby diminished. Notably, the ladders are not tested to overcome the loads resulting from getting in touch with the pilot boat.

Despite the evident significance of this practice, it has been noted during pilots' interviews that the coxswains of pilot boats do not consistently adhere to it. Additionally, 25% of the interviewed pilots preferred the boat to be positioned directly beneath the ladder during embarkation and disembarkation. This arrangement entails the boat's crew physically supporting the ladder for pilots during boarding. Nonetheless, it's worth considering that this practice could be rendered obsolete by utilising pilot ladder fixing devices affixed to the ship's side.

4.3 Analysis of pilot transfer arrangements accident factors

The accidents analysis conducted according to the integrated framework resulted from Rasmussen's risk management framework and IMO MCI circular reveals that less significant contributing factors are those that are temporary in nature, whereas the more impactful contributing factors are frequently associated with management and organisational issues. The management and organisational factors hold significant weight, accounting for 50% of all contributing factors. In contrast, temporary factors make up 6.9% of these factors, as shown in Figure 17. The management factors percentage presented combines the three main organisations engaged in the pilot transfer operation.

Figure 17 Pilot transfer arrangements contributing factors



4.3.1 Management/Organizational contributing factors

Within the realm of management and organisational factors, Safety and Environmental Management encompass 29% of this category and 14.7% of the total factors influencing pilot transfer arrangement accidents, as shown in Figure 18.

Upon delving deeper into the realm of Management/Organizational contributing factors, it becomes apparent that several salient issues arise. These issues prominently include the absence of inspection plans and the neglect to conduct internal audits. These aspects come into focus after identifying insufficient formal safety assessments and risk evaluations associated with pilot transfer operations within incidents involving pilot transfer arrangements.

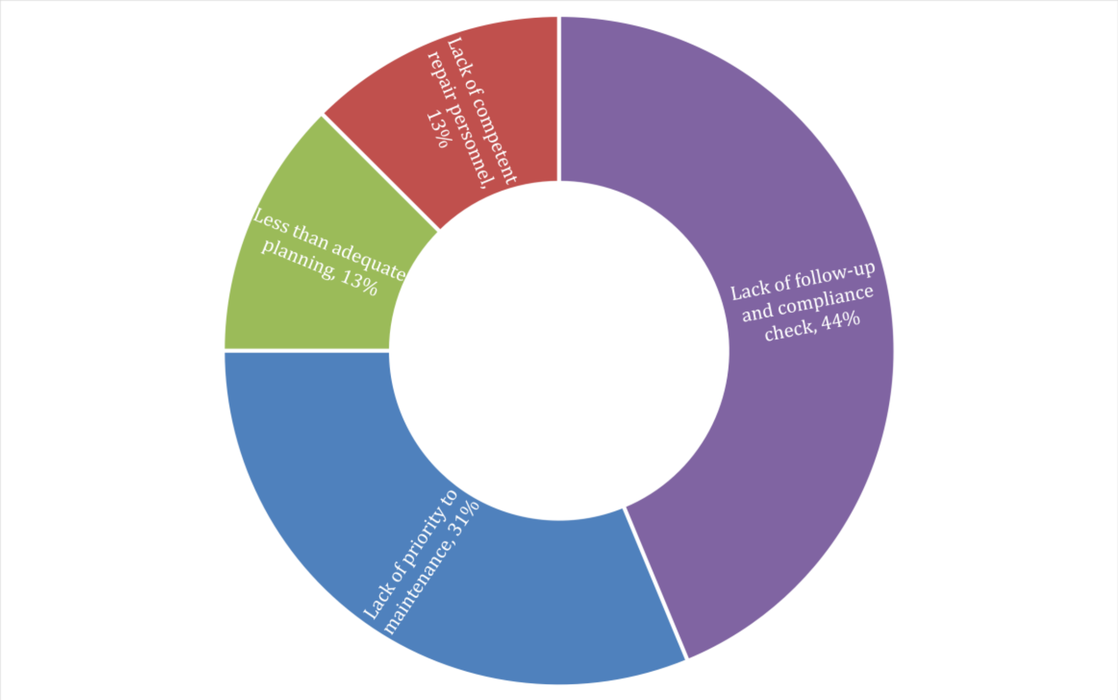
Figure 18 Management/organizational contributing factors

In certain instances, the shipping companies' management and the ship's masters have failed to carry out the requisite formal safety assessment and risk assessment for pilot transfer operations. Additionally, upon reviewing the safety management system of three shipping companies, no predefined measures were to be conducted before the pilot transfer operations. The findings was verified by three officers assigned as safety officers, and they declared that they had never done the pilot transfer risk assessment as it was not included in the company's predetermined risk assessment lists. The same also applies to the pilots' organisation and pilot boat operators. Even though this issue was not explicitly mentioned in the investigation reports, it appears during the pilot interviews that the risk assessment is not always done.

A significant gap was identified while interviewing a drydock pilot. He declared, "*The vessels' ladders are often not compliant; they are coming for repairs in the drydock, so we don't expect nice compliant ladders, and what makes it hard is that the docking schedules are always tight, we are under pressure to keep the schedule that's why we often board the vessels in unsafe conditions without performing the proper risk assessment*." The statement from the drydock pilot underscores the challenges faced in ensuring safety during vessel boarding and drydock operations. Tight docking schedules and non-compliant vessel ladders create a risk environment where safety protocols may be compromised due to schedule pressures, highlighting the need for improved safety measures and risk assessment procedures.

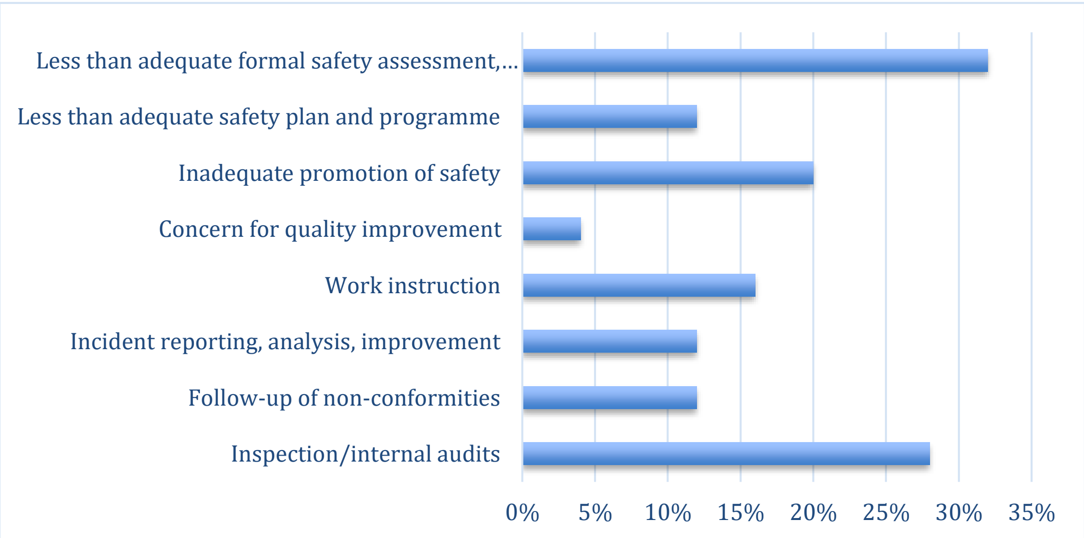
Furthermore, the maintenance policy plays a significant role, accounting for 14% of the factors attributed to management and organisational aspects, with the subfactors shown in Figure 19. A critical concern arises from the absence of comprehensive maintenance and inspection plans within SOLAS regulations. This absence emerges as a primary contributing factor that exposes a gap in management oversight regarding establishing an effective maintenance and inspection policy for pilot transfer arrangements.

Figure 19 Maintenance policy subfactors



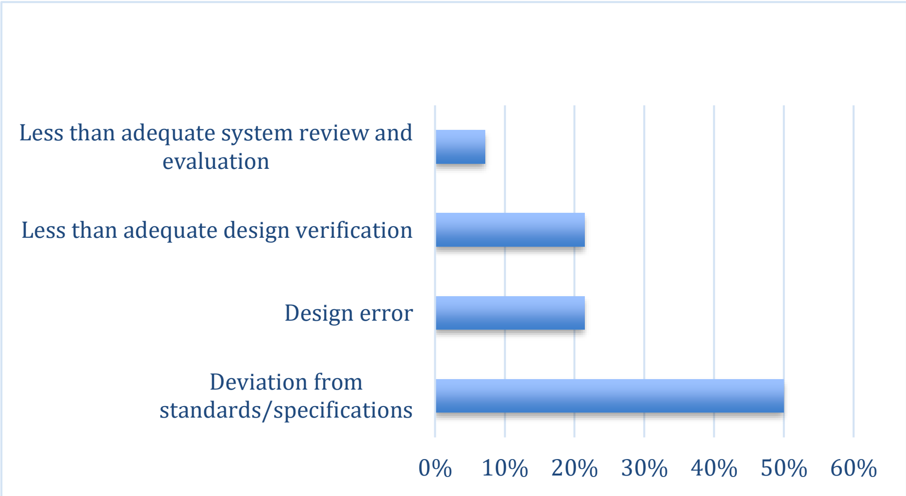
Furthermore, the inadequate pursuit of rectifying non-conformities constitutes 12% of the safety and environmental management, as mentioned in Figure 20. Notably, in three separate incidents, the pilot ladders were reported as defective. Despite these reports, these faulty ladders remained in service. Subsequent operations following these reports culminated in accidents.

Figure 20 Safety and environmental management factors



Design-related factors account for 12 % of the Management/Organizational contributing factors. Within these factors, a significant portion, precisely 50%, as shown in Figure 21, stems from deviations from established standards and specifications.

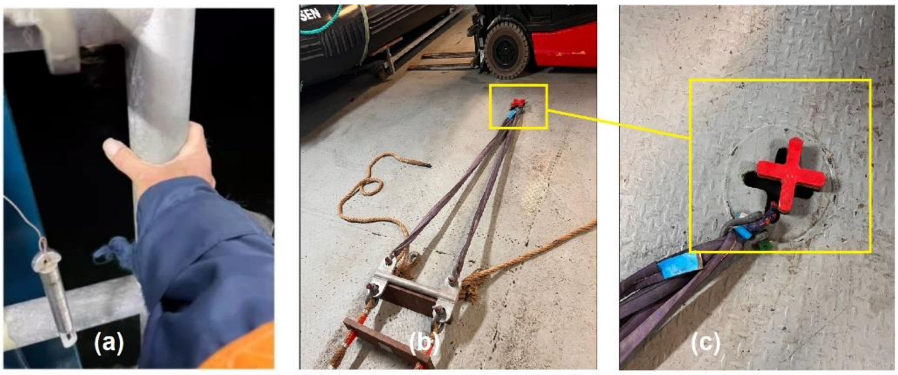
Figure 21 Design contributing factors



The main cause identified was the utilisation of deck openings other than the designed deck access. Additionally, in one case, the pilot embarkation point was not within the midship half-length and parallel body of the ship hull; the curved hull prevented the steps from resting against the ship side, and there were no provisions for handrails, stanchions, or strong points at deck level then. This highlights the issue of the flag state inspection and verification that the design has been approved despite being non-compliant with SOLAS requirements.

During the interviews, two pilots shared the photos shown in Figure 22. In photo (a), the pilot stated that the "stanchion diameter was too large to be grasped by hand and support the body weight." In photos (b) and (c), the pilot mentioned that the crew "managed to manipulate the design and make changes" and used the "cargo securing points" for fixing the pilot ladder.

Figure 22 non-compliant ladders - Design factors



Source: Posted after acceptance of pilots who shared the photos during the interviews

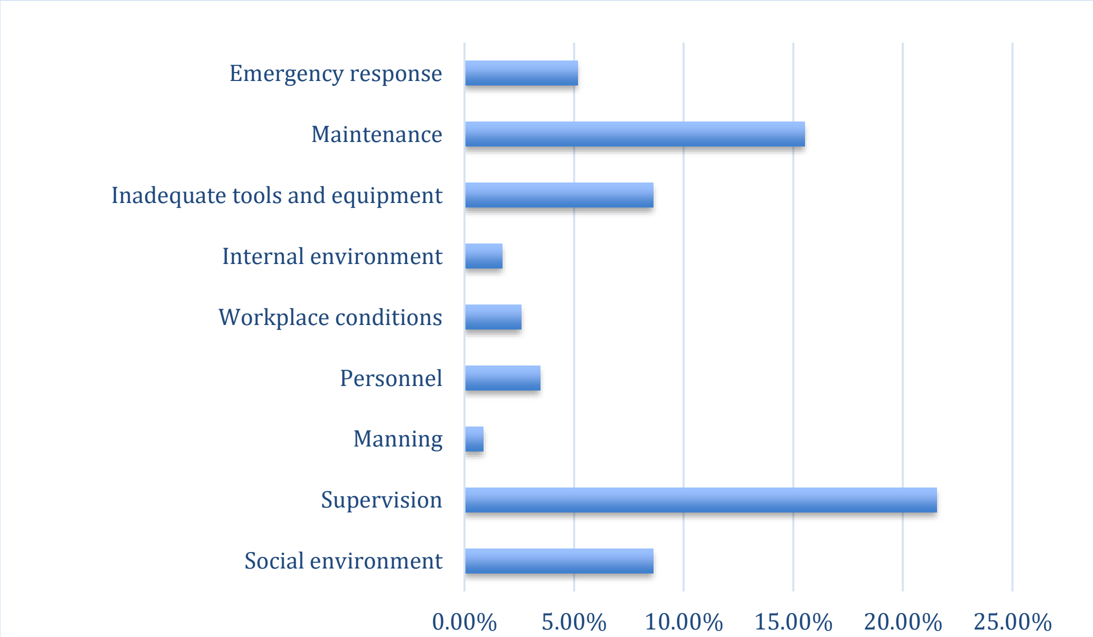
The design factors also included pilot boat design factors and their compatibility for safe transfer operation conduction. In one of the incidents, the tugboat was used to transfer the pilot to the vessel. At the forward part of the tug, a platform was used for boarding. The investigations revealed that the platform was temporarily fixed and unstable, making the pilot lose his balance and fall off the tugboat.

In another accident, when the pilot fell off the ladder into the water because of the pilot boat design, the boat crew could not recover the unconscious pilot from the water until the salvage and rescue boat arrived. The recovery was made 101 minutes after the pilot fell into the water. Even though the crew training and drill on recovery of persons from the water contributed to this accident, it was declared that the pilot boat design had also constituted a barrier against the success of the recovery operation.

4.3.2 Operational contributing factors

Operational contributing factors constitute 34.05% of the pilot transfer arrangement accidents. Supervision is the highest sub-factor among the operational contributing factors, as illustrated in Figure 23. It was revealed that the lack of supervision during the preparation of pilot transfer arrangements was evident and led to accidents, which was identified as the third contributing factor according to Aydin et al. (2022) study. In one accident, the manropes were hastily prepared, resulting in slack ropes that gave way when the pilot applied weight. The sudden movement of the ropes caused the pilot to lose balance and fall off the ladder. During the investigation, it was noted that no officer was present during the preparation stage or the transfer operation, which violates SOLAS regulations.

Figure 23 Classification of operational contributing factors



Interviews further revealed that ship masters often rely on deck cadets to oversee the preparation of transfer arrangements and the pilot transfer process. This practice persists despite SOLAS regulations mandating a responsible officer to be in charge of the operation. Notably, all of the interviewed pilots, representing 100% of them, stated that they had faced cadets or ratings supervising their transfer operations. 17% of the interviewed pilots refused to disembark without the presence of a responsible officer, as required by SOLAS regulations.

Emergency response accounted for 5% of the contributing factors. Delays in response, including reporting and requesting external assistance and coordination between the ship and the pilot boat in search and rescue operations, have contributed to accidents.

During interviews, a marine officer shared an incident during a pilot boarding operation where a deck cadet was in charge. He stated, "*The cadet reported to the* *bridge, "Pilot Overboard," when the pilot had safely boarded the vessel, and he meant to say, "Pilot onboard." The master's response was to step outside onto the bridge wing to verify whether the pilot was overboard or onboar*d”. Notably, the ship's engine was not stopped during this process, which could have resulted in a serious casualty involving the ship's propeller if it had been an actual emergency situation. This incident underscores the significance of supervision and emergency response, as they can jointly create a dangerous situation with the potential for a fatality.

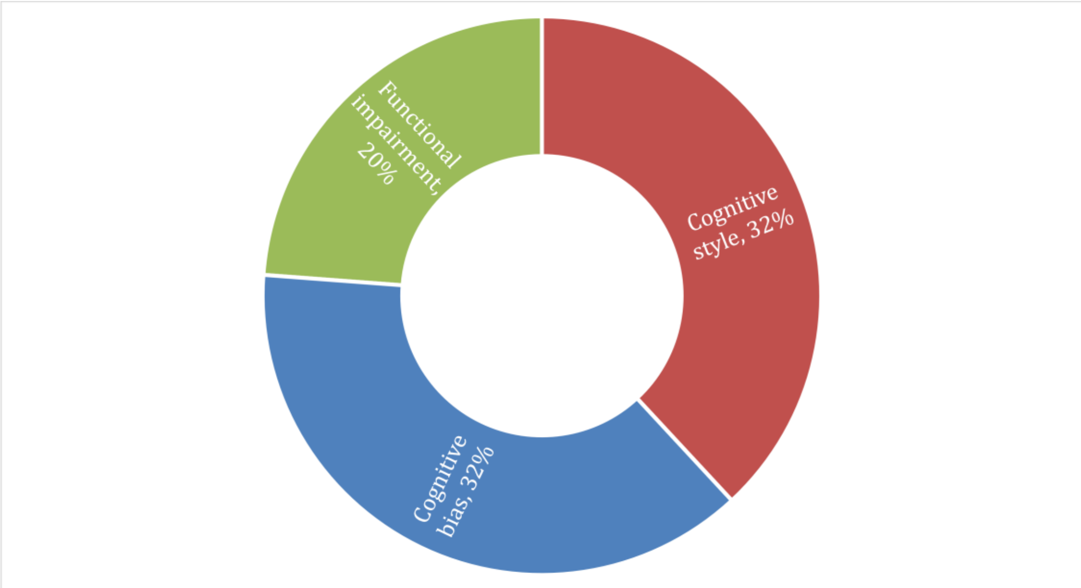
Maintenance comes as the second-highest operational contributing factor. However, the maintenance factors are occasionally combinations and derivatives from the management/organisational contributing factors due to the lack of maintenance plans and instructions or the lack of materials and resources.

4.3.3 Permanent related contributing factors

The permanent contributing factors constitute the third major contributor to pilot transfer arrangement accidents, with its subfactors illustrated in Figure 24. Cognitive bias, as identified in accident investigation reports from the ships' crew, pilots, and pilot boat crew, plays a significant role. Cognitive style shares the same percentage as cognitive bias, mainly characterised by deviations from established procedures, which have been linked to accidents.

Functional impairment contributes to 20% of the permanent related factors. Lack of alertness, concentration, decision-making and physical abilities were among the factors extracted from the accident reports. Although fatigue and inadequate rest hours were not explicitly mentioned in the accident analysis, they were revealed during interviews to play a significant role in pilot transfer arrangement accidents, particularly during nighttime operations.

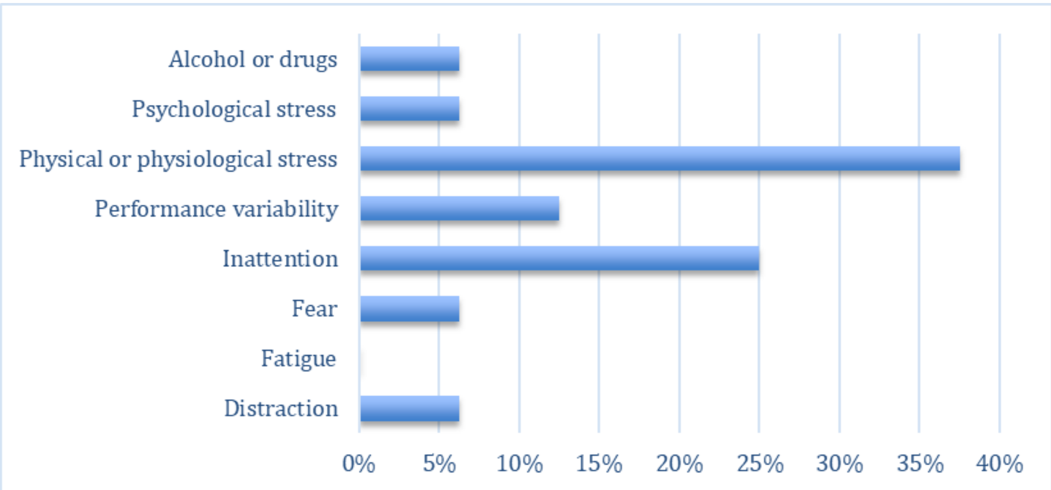
Figure 24 Permanent contributing factors



4.3.4 Temporary related contributing factors

The analysis reveals that the temporary contributing factors account for 6.9% of the overall factors influencing accidents in pilot transfer arrangements. Physical or physiological stress emerges as a significant element, contributing to 37.5% of the temporary factors, as shown in Figure 25.

Figure 25 Temporary related contributing factors



In one instance, the pilot had availed multiple periods of medical leave and underwent dual knee operations. Following both surgeries, the pilot received clearance from his private physician to resume duty. Another incident involved a pilot overdue for their medical examination by eight months. Furthermore, three separate accidents involved pilots displaying signs of physical strain while ascending the ladder, prompting them to pause briefly midway. Five of the six physical or physiological stress instances occurred during ladder embarkation. Consequently, one of the six cases resulted in injuries, whereas the remaining five culminated in fatal casualties.

Boarding vessels via the pilot ladder imposes significant physical strain and necessitates high mobility (Kitamura et al., 2014; Okazaki et al., 2010). Inadequate levels of physical ability or mobility increase the risk of pilots being unable to board successfully. This concern is especially notable in cases involving overweight or elderly pilots (Oldenburg et al., 2021), as highlighted in interviews conducted with pilots. Furthermore, the absence of well-defined medical evaluation requirements exacerbates this problem, heightening the likelihood of unsuccessful boarding attempts.

The interviews also highlighted inadequate medical examination practices among pilots. Only 25% of the respondents reported undergoing proper annual medical examinations, which, in their opinion, clearly measures the physical ability to perform the required duties. It was also noted that 33% of the interviewed pilots did not receive any medical assessments during the entire course of employment, having undergone it only once at the time of recruitment. Furthermore, the medical evaluations of none of the interviewed pilots included stress electrocardiograms (ECGs). None of the participants indicated that the current medical or physical checks assessed the pilots' ability to climb a 9-meter pilot ladder. Moreover, 75% of the respondents disclosed that their organisations lacked weight limits for pilots, resulting in the presence of overweight pilots, which posed a hazard to the successful execution of their duties.

Additionally, fear constitutes 6% of the temporary contributing factors. The lack of practical training on pilot transfer arrangements is a primary reason for the fear of using pilot transfer arrangements. Interviews with pilots revealed that, except for those at one organisation, other pilots had not undergone any practical training related to pilot transfer arrangements, and their first use of pilot ladders was on the job at sea.

In one of the accidents, the trainee pilot showed signs of fear while disembarking -as stated by the witnesses- which led to a fall from the ladder onto the boat, resulting in a fatal outcome.

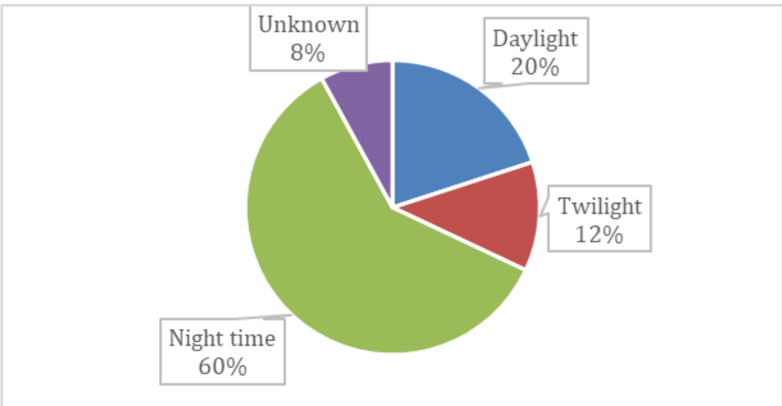
During the interviews, three pilots admitted that they experienced near misses related to pilot transfer arrangements during their training period, which were not reported to their seniors so as not to affect their performance reports. Another pilot declared that he had fallen off the ladder and into the water during his training period as his foot missed a step.

The lack of comprehensive training that includes practical training on embarkation and disembarkation may have impacted their ability to handle challenging situations effectively and led to accidents or near misses.

4.4 Natural light conditions

Based on the thorough analysis of accident reports, the time of occurrence of the accidents is shown in Figure 26.

Figure 26 Natural light conditions of the occurred accidents



Notably, the cumulative rate of accidents transpiring during night-time and twilight constitutes a substantial 72%, emphasising a need for heightened caution regarding adequate lighting. This aligns with the study conducted by Meere et al. (2005), which shows that inadequate lighting ranks among the top 5 contributing factors to accidents on board ships. And almost 4% of the pilots are carrying portable flashlights with them during the transfer operation. However, using the portable light is not possible during the embarking and disembarking, making them rely only on the fixed lights.

Additionally, 75% of the marine officers carry portable flashlights during the pilot transfer operations occurring at nighttime, as they are aware that the fixed lights are not sufficient for the safety of the operation despite their compliance with the regulations.

Adequate illumination is crucial for ensuring the visibility of transfer arrangements overside, as mandated by SOLAS Chapter V Regulation 23. Notably, this lighting requirement is conspicuously absent from SOLAS Regulations, IMO Resolution A.1045 (27) and the ISO standards. This lack of emphasis on adequate lighting characteristics within the regulations potentially leads to suboptimal illumination conditions during operations, increasing the risk of accidents, especially during nighttime hours.

In-depth interviews with marine officers and pilots provided valuable insights into the existing lighting conditions. Half of the respondents explicitly acknowledged the insufficiency of current lighting provisions, often requiring portable torchlights to supplement illumination during pilot transfer operations. Additionally, one pilot mentioned that their organisation frequently deploys tugboats as an alternative to ageing pilot boats, some of which have been in service for over two decades and are unable to withstand adverse weather conditions. Unfortunately, these tugboats lack controllable light direction, thereby failing to provide adequate lighting conditions for pilot ladders. While robust illumination may not be deemed essential solely for the boarding and disembarking phases, its role in offering clear visibility of rope and step conditions at elevated levels, a parameter often challenging to assess beforehand, cannot be underestimated.

Moreover, as highlighted by the pilots, in addition to the light role in providing illumination for transfer arrangements and deck locations, adequate lighting is essential for illuminating the sea. This illumination is crucial for determining wave directions and timing, facilitating the identification of the optimal moment for ladder boarding. Ideally, this occurs when the pilot boat is at the crest of a wave, reducing the risk of the pilot being hit by the pilot boat while on the ladder.

4.5 Malfunctioning protective barriers

The occurrence of accidents in pilot transfer arrangements has repeatedly shown a tendency to breach established safety protocols. This concern emerged prominently during the interviews, leading to more severe consequences. These outcomes can be attributed to a combination of factors, including non-compliance with proper PPE protocols and instances where faulty PPE is utilised. Furthermore, a recurring issue that exacerbates the seriousness of these accidents is the absence of robust mechanisms for the circulation of accident investigation reports and the underreporting of near misses. This deficiency in disseminating and integrating the lessons learned from past incidents significantly hinders the overarching goal of enhancing safety within the domain of pilot transfer arrangements.

4.5.1 Personal protective equipment

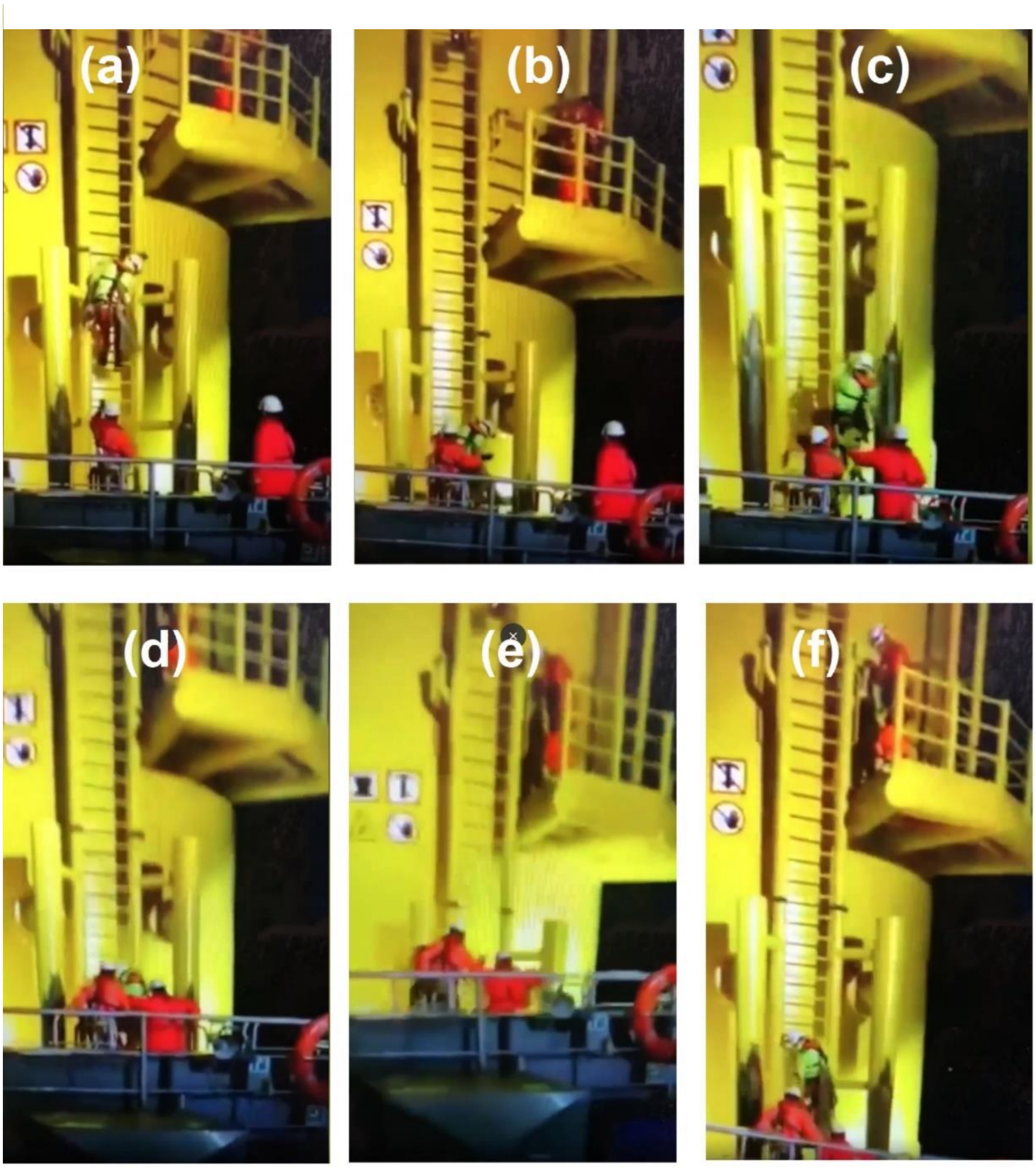
Pilots' PPE is an underrated issue. Upon analysing the accident reports, the PPE under occupational health management contributed to five accidents, including drowning casualties after falling into the water. The findings presented herein are based on comprehensive interviews with experienced pilots, focusing on the efficacy of fall prevention devices (FBD), safety harnesses, and the broader utilisation of PPE. It also explores the prevailing challenges associated with equipment maintenance and practices.

Across all individual interviews with the pilots, there was a unanimous agreement that FPD and safety harnesses might inadvertently compromise pilot safety during transfer procedures rather than providing intended safety enhancements. Notably, during the final ladder-to-boat transition, pilots encounter a critical stage wherein they may leap from the ladder to the vessel. FBD appear to introduce an element of distraction or impediment, potentially hindering pilots from effectively reaching the pilot boat. This situation could result in hazardous entrapment between the ship and the pilot boat. Consequently, the interviewed pilots uniformly favour a more streamlined approach, relying on their expertise and agility.

The risks associated with the utilisation of FPD during the disembarkation process can be effectively demonstrated through a series of six sequential snapshots, as shown in Figure 27, which have been extracted from a video recording of an individual employing an FPD while attempting to descend from a wind turbine (a fixed object) onto a vessel awaiting their arrival. The precarious nature of this operation is evident in the captured sequence. In Snapshot (a), the individual is seen cautiously waiting for the opportune moment when the vessel aligns with the crest of a wave to make the leap onto the vessel. Snapshot (b) shows the successful landing on the vessel; however, the FPD remains securely attached. In Snapshot (c), as the vessel descends with the wave, the individual becomes suspended, still connected to the FPD. Subsequent snapshots (d) and (e) reveal the vessel's erratic movements, making the individual stuck between the wind turbine and the vessel. Finally, Snapshot (f) depicts the vessel descending once more, with the individual still tethered to the FPD. This illustrative scenario underscores the potential perils associated with FPD usage during transfer operations, particularly if both vessels are subjected to significant motion in case of pilot transfers.

Instead of enhancing pilot safety, reliance on FPDs in such dynamic conditions may inadvertently lead to accidents and fatalities.

Figure 27 Sequential snapshots illustrating perils of FPD use in dynamic disembarkation



Note. Individual employing FPD while attempting to descend from a wind turbine.
Source: Posted by Arie Palmers on LinkedIn

Pilots consistently indicate their adherence to a select range of PPE that has proven efficacious in ensuring their safety during transfer operations. This PPE ensemble encompasses safety shoes with anti-slip properties, gloves, hard hat helmets, and inflatable life jackets. However, the study of accident reports has unearthed instances wherein pilots were found without proper PPE, such as lacking anti-slip shoes and inflatable lifejackets, a clear departure from recommended safety protocols. Additionally, two noteworthy incidents involving inflatable lifejackets came to light. In the first instance, a lifejacket failed to inflate, and in the second, a lifejacket, when inflated, inadvertently positioned an unconscious pilot's head underwater, tragically leading to drowning.

A significant aspect that emerged from the interviews pertains to the maintenance of inflatable life jackets. A remarkable 75% of the interviewed pilots revealed that their inflatable lifejackets had not been subjected to requisite checks or replacements by either pilot authorities or manufacturers. Furthermore, some pilots confessed to using the same lifejacket for up to three years without any inspection.

This phenomenon raises concerns as it contradicts the regulations stipulated in SOLAS Chapter 3 Regulation 20.8.1.1. This regulation mandates the evaluation of inflatable life jackets at approved servicing stations equipped with proper servicing infrastructure and personnel proficient in their maintenance. The required interval for such checks is 12 months, with a potential extension to 17 months.

A gap between recommended maintenance protocols and practices, particularly concerning the maintenance and inspection of inflatable lifejackets, raises pressing concerns. Adherence to the maker’s periodic inspections recommendations is pivotal in ensuring the reliability of safety equipment.

Upon further investigation of the pilot's PPE used during the boarding or embarkation, several cases came to light through social media posts and videos. The lack of proper PPE was highlighted on several occasions while using ladders, as shown in Figure 28. Among the 50 posts of pilots using pilot ladders, it was observed that eight different users had shared photos or videos showing the absence of appropriate PPE, constituting 16% of the observed sample. This deficiency in safety precautions poses a significant concern.

Figure 28 Using of backpacks and lack of PPE while using pilot ladders

Note The lack of PPE while using pilot ladders

Source: Various posts on social media

In the depicted photos, a recurrent issue is the absence of hard hats, posing a significant risk of head injury in case of falls onto hard surfaces or falling objects such as parted ladders, as shown in figure (i). In photos (a), (b), (h) and (d), the use of inappropriate anti-slip safety footwear is noticeable. In Figure (d), sandals are observed. Such improper footwear increases the risk of slipping, particularly on wet ladder surfaces. It raises concerns about foot entrapment between the boat and the ship during transfer operations, potentially leading to severe injuries.

Moreover, three photos (a, c, and d) show individuals without gloves, a crucial element for ensuring a secure handhold during the transfer. In Figure (f), cotton gloves are used, which may compromise grip stability and increase the risk of slipping and falling from the ladder. An interview provided insight into a UK accident where a pilot lost his grip and fell from a ladder, attributing the incident to inadequate glove quality. Subsequently, the pilot organisation replaced all gloves with a more suitable model, underscoring the importance of using the proper type of gloves during transfer operations.

Additionally, it was noted that in six out of the eight pictures, the pilots were seen using backpacks or shoulder bags while boarding, which have the potential to generate momentum due to swinging motions. It is hypothesised that the use of additional loads, such as bags, may have an impact on climbing biomechanics. Notably, under heavier loads, some participants were observed to undergo rotational motion in conjunction with the swinging motion of these external loads. This phenomenon could potentially affect the force exerted through their hands, required for maintaining balance, and could lead to increased localised fatigue (Barron, 2019).

Among the interviewed pilots, 33% acknowledged that their organisations have clear instructions prohibiting the use of additional weights while using the ladders. Another 33% declared they do not carry additional weights and rely on heaving lines to pick up or lower extra weight. The remaining stated that they use their lightweight backpacks, which they believe do not compromise the safety of the operation.

During the interviews conducted with marine officers, all the interviewees declared that they had participated in pilot transfer operations where the pilots were not using the proper PPE. When asked about their reactions, they stated that they did not report it to the masters, who declared they had no real power to stop the pilot from embarking or disembarking the ladder because of not wearing PPE. It would endanger the vessel’s safety, particularly when the pilot is boarding in critical boarding areas.

4.5.2 Lack of no-blame culture and near-miss reporting

Interviews conducted with pilots from various organisations unveiled the existence of accident and near-miss reporting systems. However, only 25% of these pilots affirmed the practical implementation of such reporting systems. Notably, 75% of pilots admitted to refraining from reporting near-misses and solely communicating actual accidents that do not lead to injuries or fatalities. One pilot recounted an incident from his initial year as a pilot, where he fell into the water due to a misstep on the ladder while boarding a vessel. However, he opted not to report the accident to the pilot authority. He boarded the vessel fully drenched and manoeuvred the vessel to the berth to avoid jeopardising his career. The pilot added, *"I made the decision to board the vessel and manoeuvre it to the berth since it had already entered the channel. My primary concern was ensuring port safety, especially considering that I was the only pilot on the boat at that moment."*

A prevailing observation from the interviews was the absence of a real no-blame culture in the majority of pilot associations. This indicates a potential gap in sharing crucial safety information among pilot communities. It was also noted that whenever near-misses are reported, they are not always circulated among the organisation as part of the safety meetings to analyse the root causes, the lessons learned, and the preventive measures to avoid a reoccurrence.

4.5.3 Non-compliant pilot transfer arrangements reporting

Upon interviewing pilots about their actions whenever they determine a non-compliant ladder, 83% declared that they refuse to board until it is ratified on the spot. However, upon their further actions, only 16% of the interviewed pilots declared that they had reported it to the authorities. Regardless, all the pilots stated they had clear instructions to report non-compliant ladders to the authorities.

The low reporting rate that emerges from the interviews aligns with the low reporting rates presented in the IMPA reports to the IMO. Upon analysing the reasons behind that action, it was revealed by 25% of the pilots that they all have seafarers' backgrounds, and they understand that the seafarers do not like to be imposed on port state control. 42% of the pilots responded that they don't have a clear justification for that and stated, "If the ladder is ratified, then there is no need to report it".

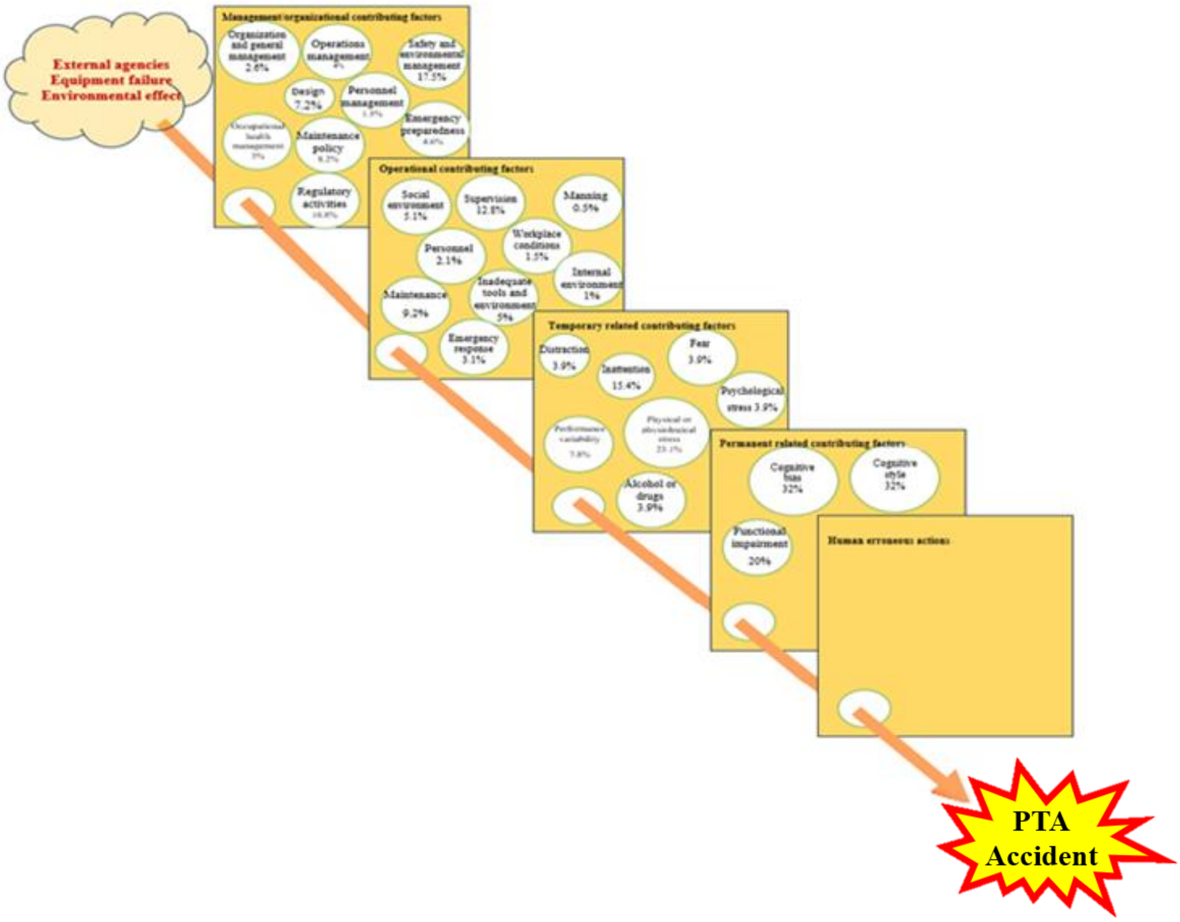
4.6 Synthesis of results and discussions

Following the detailed examination of individual elements that contributed to the pilot transfer arrangements accidents, it becomes evident that a broader framework is essential to provide a holistic perspective. While dissecting the micro-level components is valuable, there arises a requirement for a macro-level view to encompass the larger picture of pilot transfer arrangement accidents. This transition leads us to the subsequent sections dedicated to synthesising the results and discussions.

4.6.1 Rasmussen's risk management framework

The findings have been presented within the context of Rasmussen's risk management framework, as shown in Figure 29. However, Rasmussen's risk management framework primarily centres on human erroneous actions. It is important to note that human actions are influenced by higher-tier contributing factors, as well as external factors such as external agencies, equipment failures, and environmental impacts.

Figure 29 Pilot transfer arrangements accidents contributing factors distribution



Notably, it was observed that Rasmussen's risk management framework has limitations that hinder its ability to fully demonstrate all the linkages and interactions among the various contributing factors to pilot transfer arrangements accidents. These limitations are intrinsic to the framework itself. Rasmussen's risk management framework was originally designed for accidents that follow linear or chain-of-events patterns, as discussed by Dallat et al. (2019). In contrast, the pilot transfer operation is a socio-technical system, and accidents in this context often involve non-linear and dynamic causal relationships. While Rasmussen's risk management framework does address certain aspects of causality related to human performance, it does not sufficiently capture the intricacies of causation within a system-thinking framework (Cassano-Piche et al. 2009).

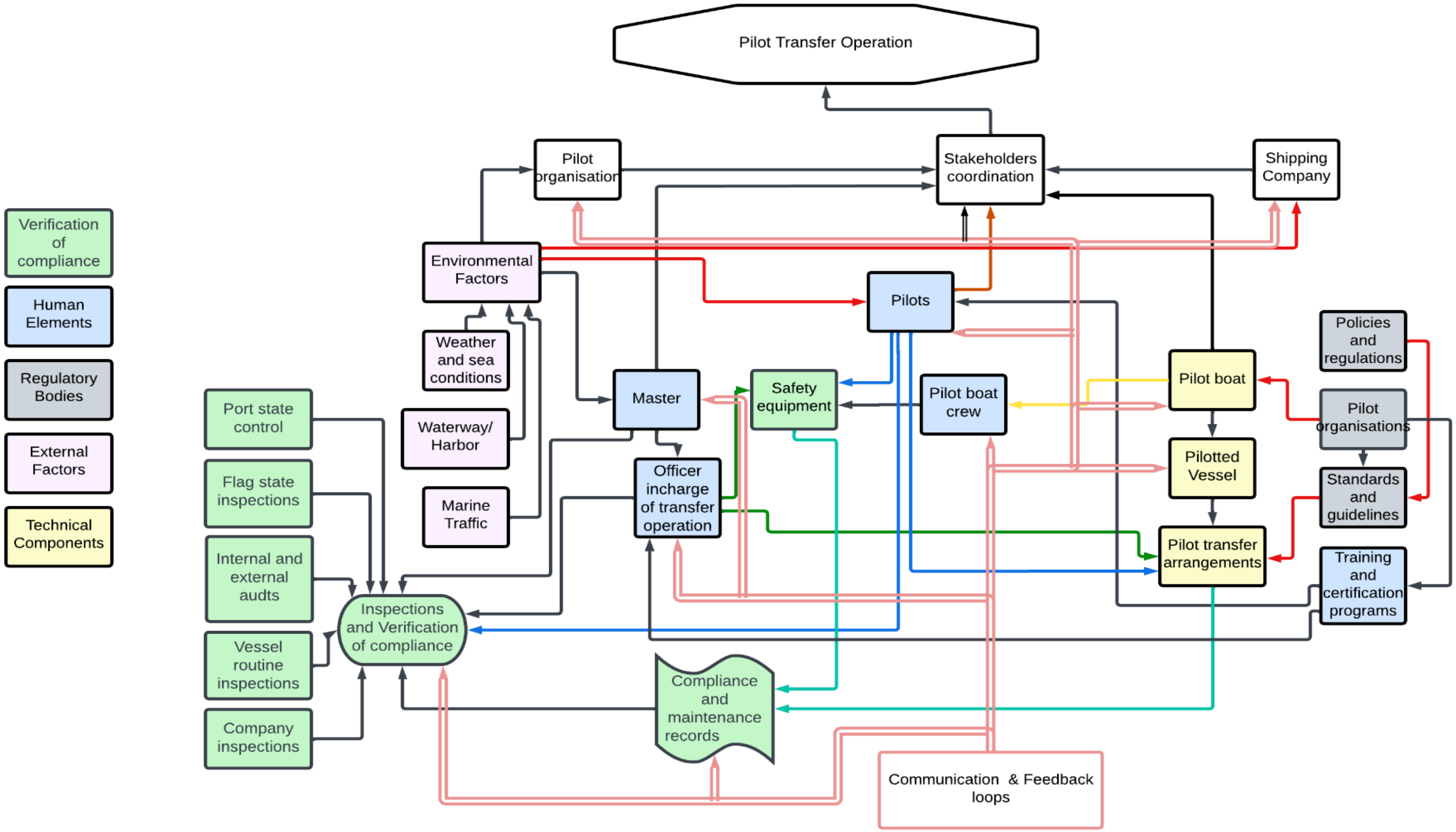
In conclusion, while Rasmussen's risk management framework serves as a valuable analytical tool for understanding human-related aspects of risk in complex systems, its limitations become apparent when dealing with non-linear, dynamic, and emergent factors. To comprehensively address the complexities of pilot transfer arrangement accidents, the application of the STAMP model approach framework is required to consider the broader spectrum of contributing factors and their dynamic interactions.

4.6.2 Application of STAMP model to pilot transfer arrangements accidents

The application of the STAMP model to synthesise pilot transfer arrangement accident findings has brought about notable advancements in our understanding of these accidents. It has shifted our perspective from viewing accidents as mere outcomes of individual mistakes or isolated incidents to recognising them as systemic failures. The STAMP model underscores several critical aspects during the analysis of the accidents and interviews. It enabled the study to show that accidents occur in the broader context of the system, focusing on how the entire system functions and interacts rather than pinpointing blame on individuals. Additionally, the STAMP model highlights the influence of organisational and management factors on system safety. It underscores decisions, communication, and organisational culture which enhance or undermine safety and can contribute to accident occurrences.

This perspective is depicted in Figure 30, which illustrates the systemic nature of pilot transfer arrangement accidents, considering the multifaceted elements that contribute to accident events.

Figure 30 Author's application of the STAMP model to socio-technical system accidents in pilot transfer arrangements



However, it is crucial to acknowledge certain limitations in the STAMP model when applied to pilot transfer arrangements. While the model effectively portrays the ideal functioning of a healthy system, it appears to fall short in identifying the strengths of factors contributing to accidents and uncovering the faulty interactions between system elements.

An integrated approach is, therefore, proposed to overcome these limitations and gain a deeper understanding of the pivotal components within the pilot transfer arrangements socio-technical system. This proposed approach combines the STAMP model with Rasmussen's risk management framework in a Sankey diagram, creating a comprehensive framework synthesising the findings and discussions. This innovative approach aims to address the identified shortcomings and pave the way for safer pilot transfer arrangements and operations.

Chapter 5 SAFEPILOT framework

5.1 Introduction

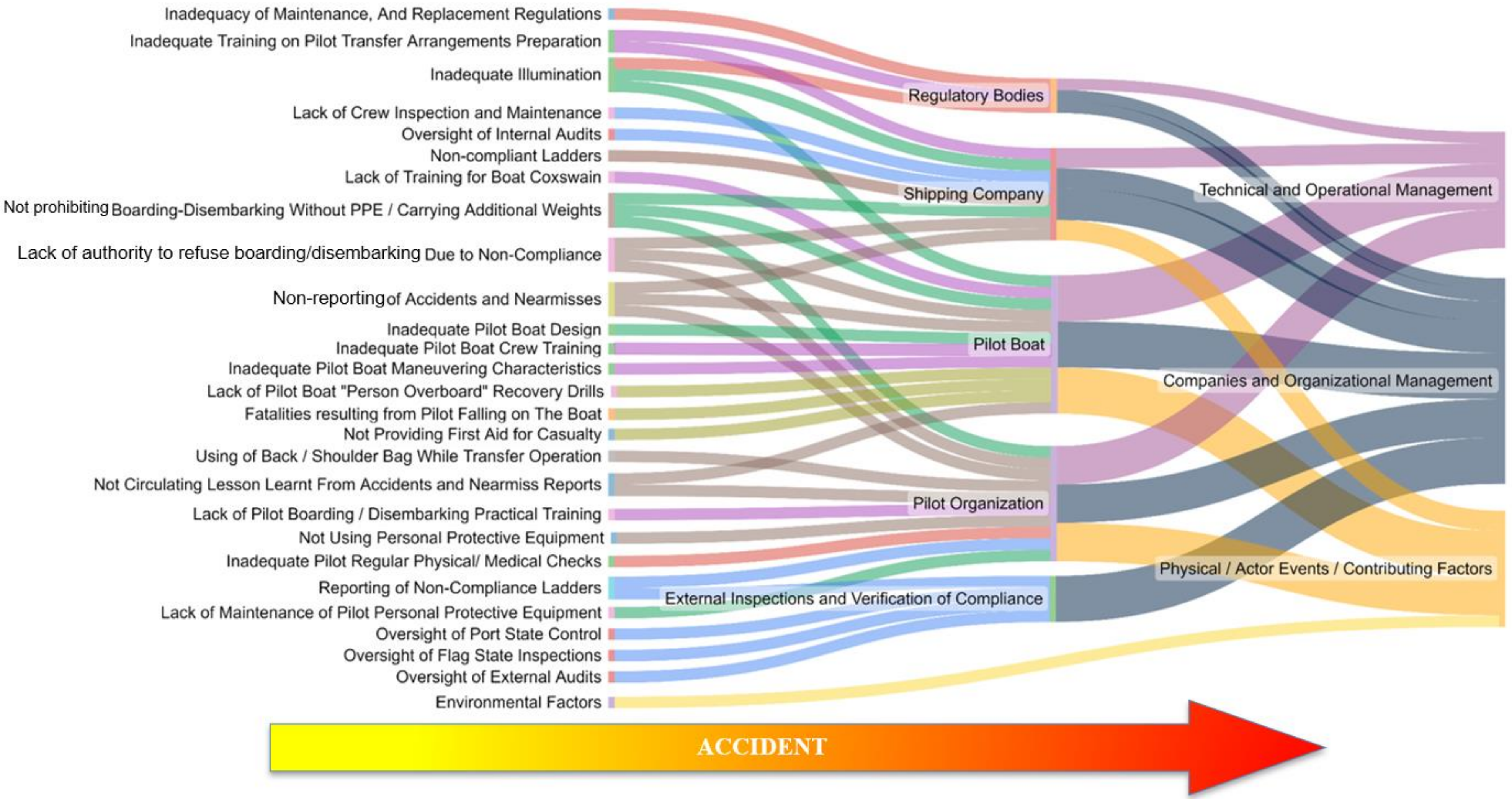
Building upon the preceding chapter, this chapter aims to enhance pilot transfer arrangements safety appraisal by synthesising the findings from the accident reports and integrating experts' perspectives gathered through the interviews into a conceptual framework to provide further insights and enhance pilot transfer arrangements safety.

By integrating the STAMP model and Rasmussen's risk management framework in a Sankey diagram the resulting framework will be able to demonstrate the intricate relationships and flows within the system, shedding light on strengths and weaknesses. This holistic view is expected to enhance the ability to proactively manage risks, ultimately contributing to the safety and efficiency of pilot transfer arrangements.

5.2 Synthesis of the findings in the integrated framework

The model encompasses multiple layers for categorizing accidental factors and identifying the interplay among the various stakeholders engaged in pilot transfer operations. This framework effectively monitors and tracks the pressure points within the pilot transfer arrangement system in either direction for controlling and managing the associated risks and establishing mitigation strategies, as shown in Figure 31.

Figure 31 Synthesizing accident factors in pilot transfer arrangements: The resultant Sankey framework



- The first layer identifies the critical pressure points within the pilot transfer arrangements socio-technical system. These pressure points are classified into seven distinct categories, which are coded as mentioned in Table 4.

Table 4 1st flow colour code

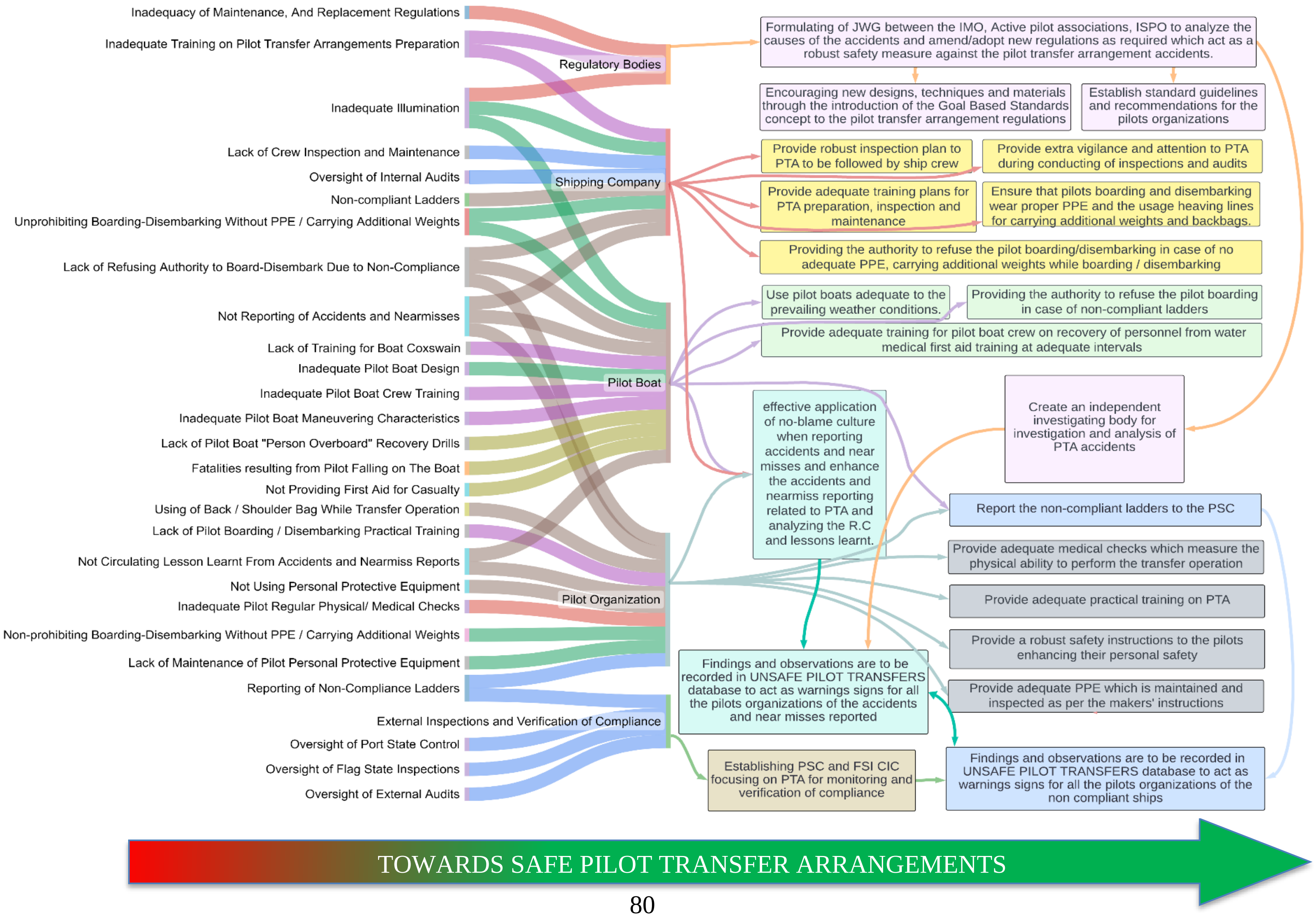
Inspections and Verification Factors	
Regulatory Factors	
Operational Factors	
Training Factors	
Emergency Response Factors	
Safety Culture Factors	
Environmental Factors	

- The second layer identifies the stakeholders' shared responsibility for the identified factors, which will then be used to address the proposed safety measures to ensure the safety of the pilot transfer arrangements.
- The third layer is the classification of factors according to Rasmussen's risk management framework to have a comprehensive approach to understanding, assessing, and managing risks in the pilot transfer arrangement complex socio-technical system.

5.3 An integrated SAFEPILOT framework

The SAFEPILOT framework ensures that accident factors affecting the safety of the pilot transfer arrangements are being effectively captured and mitigated through the mutual relationships between the various organisations engaged in the pilot transfer operation. This enables the intervention of strategies to mitigate the risks associated with pilot transfer arrangements systematically, including continuous monitoring and assessing risks obtained and implementing risk mitigation controls, as shown in Figure 32.

Figure 32 SAFEPILOT framework



The SAFEPILOT framework serves as a structured foundation for enhancing safety in pilot transfer arrangements by facilitating effective identification and mitigation of accident factors. This is achieved through collaborative engagement among the various organisations involved in pilot transfer operations.

The framework ensures a comprehensive and proactive approach to accident prevention by integrating the recommendations outlined. Initiatives like the joint working group and the cultivation of a no-blame reporting culture are integral to this approach, fostering continuous enhancement of pilot transfer arrangements procedures. These measures are designed to reduce risks and promote best practices by emphasising the significance of adequate training, proper PPE usage, and compliant pilot transfer arrangements. Additionally, the SAFEPILOT framework incorporates essential elements, including an independent investigative body and a centralised database for reporting and circulating incidents and lessons learned.

Ultimately, the SAFEPILOT framework provides a systematic means to assess, monitor, and control risks, thus creating a safer environment for pilot transfer operations while seamlessly integrating the recommended interventions into the process.

Chapter 6 Conclusion and recommendations

6.1 Concluding remarks

The pilot transfer arrangement accidents have persisted for an extended period, posing a serious threat to pilot safety, with the majority of these accidents resulting in severe consequences. This research sought to address this pressing concern by identifying the factors contributing to pilot transfer arrangement accidents and devising a robust framework to enhance safety and reduce the associated risks in pilot transfer operations.

In contrast to prior studies, this study embraced a system thinking approach to analyse pilot transfer arrangement accidents. This approach allowed us to delve into the interactions among the organisations involved in pilot transfer operations and pinpoint deficiencies within the elements of the various organisations and their interaction within the system. The accident report analysis integrated Rasmussen's risk management framework and IMO MCI circular.

The analysis of contributing factors to accidents in pilot transfer arrangements reveals critical insights into the safety landscape of the operations. Management and organisational factors constitute a substantial portion, accounting for 50% of the contributing factors. This underscores the pivotal role of effective leadership, policies, and organisational culture in promoting safety within the pilot transfer arrangements context. Operational factors, at 34.05%, also play a significant role, highlighting the importance of well-defined procedures and practices in reducing risks. Additionally, permanent and temporary related contributing factors, though comparatively smaller percentages at 9.05% and 6.90%, respectively, indicate the need for ongoing attention to equipment maintenance and temporary conditions. The findings emphasise the imperative for a holistic safety approach encompassing management, operations, and the continuous assessment and mitigation of temporary and permanent factors in pilot transfer arrangements.

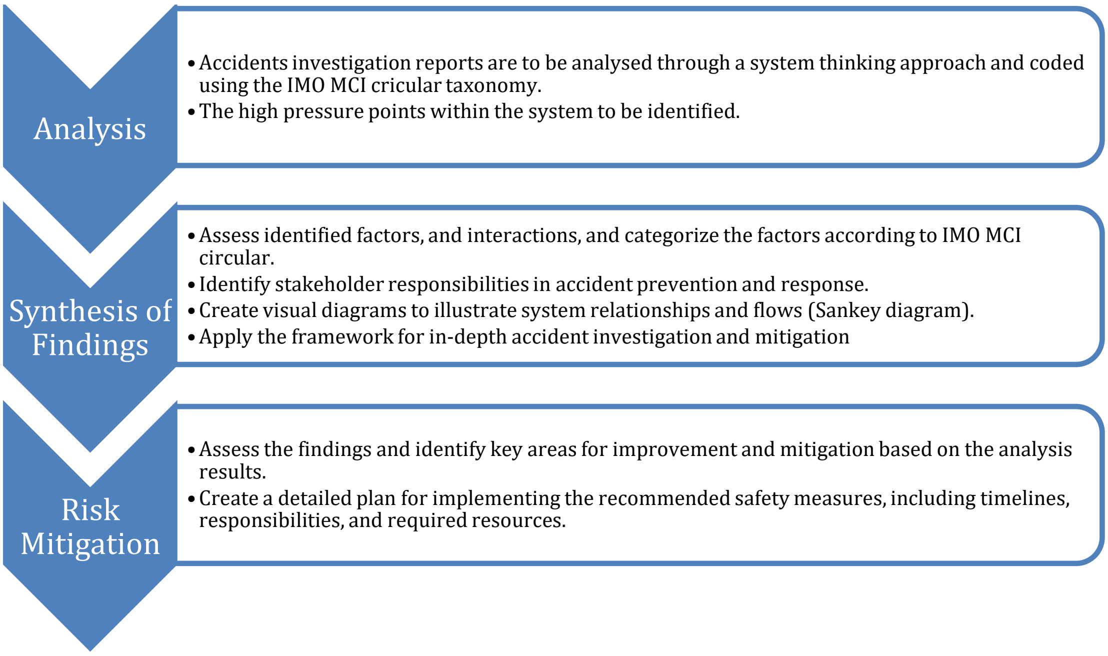
In conclusion, based on our analysis of accidents and interviews conducted, the study introduced the SAFEPILOT framework as a solution to address the factors contributing to accidents and eliminate them. Its successful implementation necessitates collaboration among all stakeholders involved in pilot transfer operations to achieve the highest levels of safety in pilot transfer arrangements and reduce risks.

This research is of paramount significance in the broader context of maritime safety. By shedding light on the importance of the system thinking approach in maritime accident investigations and its associated studies for determining the root causes and proposing comprehensive frameworks for mitigation. It contributes to the safety and efficiency of maritime operations as a whole. Ensuring the safety of all the critical aspects of the maritime industry, this study offers valuable insights and solutions that can potentially save lives, protect the environment, and reduce accidents in this vital industry.

6.2 Maritime safety analysis recommendations

To expand the applicability of the SAFEPILOT framework and adapt it for use in diverse maritime accident scenarios, it is proposed to rename it as the Maritime Incident Safety Analysis Framework (MARISAFETY). This updated framework is designed to systematically assess different maritime incidents and formulate effective mitigation strategies. This model follows a structured approach, as depicted in Figure 33, providing a roadmap for comprehensively understanding the causes and consequences of maritime accidents. Through this systematic process, it becomes possible to uncover crucial insights and develop effective strategies for enhancing safety and preventing future incidents within the maritime industry.

Figure 33 Application of MARISAFETY framework to maritime accidents



The MARISAFETY framework, offers distinct advantages over other frameworks for maritime accident analysis. Its comprehensive and systematic approach ensures a thorough understanding of accidents, reducing the risk of oversight. The inclusion of visual representations enhances clarity in complex scenarios. Moreover, MARISAFETY emphasizes stakeholder engagement and shared responsibility, promoting collaboration for accident prevention. The framework's integration of risk assessment methodologies further strengthens its ability to identify, assess, and mitigate risks effectively, ultimately making it a superior choice for enhancing maritime safety.

6.3 Pilot transfer arrangements safety recommendations

The author acknowledges that the implementation timeline for various recommendations may vary. Therefore, these recommendations have been categorised into three phases: short-term, medium-term, and long-term. It is imperative that each recommendation is not only effectively implemented but also consistently maintained. As a collective effort, these recommendations are poised to substantially enhance pilot transfer operations' safety.

Short-term Recommendations (Immediate Implementation): The short-term recommendations are an integral part of the SAFEPILOT framework diagram and can be promptly executed to significantly enhance the safety of pilot transfer arrangements.

Medium-term Recommendations (Moderate-term Focus): A comprehensive Pilot Transfer Arrangements Code is recommended to consolidate existing regulations governing these procedures. This endeavour should be informed by a system thinking approach, addressing safety concerns and streamlining regulations. Additionally, formulating robust standards for pilot organisations covers all pilot safety and well-being aspects.

Longer-term Recommendations (Sustainable Enhancement): In the longer term, there is a need to foster innovation in the pilot transfer operations field. Encouraging researchers and industry innovators to explore safer methods for pilot transfers is essential. Additionally, it is crucial for industry stakeholders to move away from the grandfathering concept and be open to adopting new industrial innovations.

6.4 Limitations of the study

While striving to contribute to maritime safety, this research acknowledges several limitations. Firstly, the study heavily relies on available accident reports and data, and it's important to note that the number of accidents reports available for analysis was limited. Variability in the completeness and accuracy of these reports may have impacted the comprehensiveness of our analysis. Secondly, the research primarily focuses on pilot transfer arrangement accidents. While these incidents are undoubtedly significant for maritime safety, future research could explore a broader range of maritime accidents to gain a more holistic understanding of system thinking factors at play. Lastly, though insightful, the interviews conducted for this research were limited in number. Therefore, they might not fully represent the maritime industry's diverse perspectives and experiences.

6.5 Recommendations for future research

Looking ahead, there are several promising avenues for future research in the realm of maritime safety. Firstly, researchers could delve deeper into advanced risk assessment methodologies explicitly tailored to pilot transfer arrangements. The application of MARISAFETY can be applied in studying various maritime accidents for enhancing the maritime safety.

Furthermore, future research might also develop new techniques for safer transfer operations, which is a pertinent area of study. Lastly, exploring opportunities for international collaboration to share best practices and safety innovations in pilot transfer arrangements can further enhance safety in this crucial aspect of maritime operations.

Addressing these limitations and pursuing these avenues of future research can contribute to ongoing efforts to enhance safety in pilot transfer arrangements and maritime operations on a global scale.

References

Abreu, D. T. M. P., Maturana, M. C., Droguett, E. L., & Martins, M. R. (2022). Human reliability analysis of conventional maritime pilotage operations supported by a prospective model. *Reliability Engineering and System Safety, 228*. https://doi.org/10.1016/j.ress.2022.108763

Adhita, I. G. M. S., & Furusho, M. (2021). Ship-to-Ship Collision Analyses Based on Functional Resonance Analysis Method. *Journal of ETA Maritime Science*, *9*(2), 102–109. https://doi.org/10.4274/jems.2021.43660

Akyuz, E. (2015). A hybrid accident analysis method to assess potential navigational contingencies: The case of ship grounding. *Safety Science*, *79*, 268–276. https://doi.org/10.1016/j.ssci.2015.06.019

Akyuz, E., Akgun, I., & Celik, M. (2016). A fuzzy failure mode and effects approach to analyse concentrated inspection campaigns on board ships. *Maritime Policy & Management*, *43*(7). https://doi.org/10.1080/03088839.2016.1173737

Amy. (2020, October 24). *Harbor Pilot for the Day in Suape*. Out Chasing Stars. Retrieved June 15, 2023, from https://outchasingstars.com/harbor-pilot-for-the-day-in-suape/

Australian Maritime Safety Authority. (2023). Pilot Transfer Arrangements – Marine Notice 04/2023. *Port Procedures and Information for Shipping – Bundaberg*. https://www.publications.qld.gov.au/ckan-publications-attachments-prod/resources/5504c30a-ebab-47c2-8cec-25e38c323cdf/bundaberg_ppm_july_2023-sec-16.1.pdf?ETag=ef3714f10bb2635710ca15c544b94da4

Aydin, M., Uğurlu, Ö., & Boran, M. (2022). Assessment of human error contribution to maritime pilot transfer operation under HFACS-PV and SLIM approach. *Ocean Engineering*, *266*. https://doi.org/10.1016/j.oceaneng.2022.112830

Bahamas Maritime Authority. (2022, April 13). *CIC on Pilot Transfer Arrangements 2021-Results Analysis Report*. *Information Notice 25*. https://www.bahamasmaritime.com/wp-content/uploads/2022/04/IN025-CIC-on-Pilot-Transfer-Arrangements-2021-Results-Analysis-Report-v1.0.pdf

Barron, P. J. (2019). *The demands of vertical ladder ergometer climbing relating to the wind energy industry* [Ph.D. thesis, Robert Gordon University]. https://rgu-repository.worktribe.com/output/841001

Behforouzi, M. (2021). Implementation of Smart Pilotage to Safeguard Pilots from Pilot Ladder Accidents. *Pomorski Zbornik*, *60*, 65–84. https://hrcak.srce.hr/file/379607

Berg, H. P. (2013). Human Factors and Safety Culture in Maritime Safety (revised). *TransNav, the International Journal on Marine Navigation and Safety of Sea Transportation*, *7*(3), 343–352. https://doi.org/10.12716/1001.07.03.04

Borges, S. F. D. S., Albuquerque, M. A. F. De, Cardoso Junior, M. M., Belderrain, M. C. N., & Costa, L. E. L. Da. (2021). Systems Theoretic Process Analysis (STPA): a bibliometric and patents analysis. *Gestão & Produção*, *28*(2). https://doi.org/10.1590/1806-9649-2020v28e5073

Broers, H. (2021). *From Regulations and Guidelines to "Safety as a Total System."* Pilotladder Safety. Retrieved July 15, 2023, from https://pilotladdersafety.com/from-regulations-and-guidelines-to-safety-as-a-total-system/

Camliyurt, G., Choi, S.-A., Kim, S.-R., Guzel, A. T., & Park, Y.-S. (2022). Risk Assessment for Marine Pilot Occupational Accidents using Fault Tree and Event Tree Analysis. *Journal of Navigation and Port Research*, *46*(5), 400–408. https://doi.org/10.5394/KINPR.2022.46.5.400

Cariou, P., & Wolff, F.-C. (2015). Identifying substandard vessels through Port State Control inspections: A new methodology for Concentrated Inspection Campaigns. *Marine Policy*, *60*. https://doi.org/10.1016/j.marpol.2015.05.013

Cassano-Piche, A. L., Vicente, K. J., & Jamieson, G. A. (2009). A test of Rasmussen's risk management framework in the food safety domain: BSE in the UK. *Theoretical Issues in Ergonomics Science*, *10*(4), 283–304. https://doi.org/10.1080/14639220802059232

Celik, M., Lavasani, S. M., & Wang, J. (2010). A risk-based modelling approach to enhance shipping accident investigation. *Safety Science*, *48*(1), 18–27. https://doi.org/10.1016/j.ssci.2009.04.007

Che Ishak, I., Azlan, M. F., Ismail, S. B., & Mohd Zainee, N. (2019). A study of human error factors on maritime accident rates in maritime industry. *Asian Academy of Management Journal*, *24*(Supp. 2), 17–32. https://doi.org/10.21315/aamj2019.24.s2.2

CHIRP. (2020). Pilot Ladders – Error Enforcing Conditions and Deficiencies. *Maritime Advisory Board*. http://ukmpa.org/wp-content/uploads/2019/04/20190401-Pilot-Ladders-Error-Enforcing-Conditions-Final.pdf

Clarksons. (2023). World Fleet Register. In *Clarksons Research*. https://www.clarksons.net/wfr/fleet

Class NK. (2023, July). *Technical Information on PSC*. https://www.classnk.or.jp/hp/en/psc/tech_main_psc.aspx

Dallat, C., Salmon, P. M., & Goode, N. (2019). Risky systems versus risky people: To what extent do risk assessment methods consider the systems approach to accident causation? A review of the literature. *Safety Science*, *119*, 266–279. https://doi.org/10.1016/j.ssci.2017.03.012

Demirci, S. E., Canımoğlu, R., & Elçiçek, H. (2022). Analysis of causal relations of marine accidents during ship navigation under pilotage: A DEMATEL approach. *Proceedings of the Institution of Mechanical Engineers, Part M: Journal of Engineering for the Maritime Environment*. https://doi.org/10.1177/14750902221127093

Dreany, H. H., & Roncace, R. (2019). A cognitive architecture safety design for safety critical systems. *Reliability Engineering & System Safety*, *191*, 106555. https://doi.org/10.1016/j.ress.2019.106555

Ernstsen, Musharraf, & Nazir. (2018). Bayesian Model of Operator Challenges in Maritime Pilotage. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *62*(1), 1813–1817. https://doi.org/10.1177/1541931218621411

Ferrarello, L., Hall, A., Kann, M., & Lee, C. H. (2017). Collaborating Design Risk. *Research IASDR 2017*, 375–388. https://researchonline.rca.ac.uk/2914/1/Ferrarello_Hall_%201360.pdf

Flynn-Evans, E. E., Arsintescu, L., Gregory, K., Mulligan, J., Nowinski, J., & Feary, M. (2018). Sleep and neurobehavioral performance vary by work start time during non-traditional day shifts. *Sleep Health*, *4*(5). https://doi.org/10.1016/j.sleh.2018.08.002

Gaillard, A. (2022). *Accidentology Study in maritime pilot boarding*. French Federation of Maritime Pilots. Retrieved July 30, 2023, from https://www.impahq.org/sites/default/files/content-files/Capt.%20Andr%C3%A9%20Gaillard.pdf

Getty Images. (2023). *Pilot Aboard*. Central Press / Stringer - Getty Images. https://www.gettyimages.ae/detail/news-photo/river-pilot-from-the-pla-pilot-station-at-gravesend-kent-news-photo/3402714

Gosling, J. (2023). (Host) Maritime Pilot Safety and reducing the risk in pilot transfer operations (Season 1 Episode 2). [Audio podcast episode]. *Sea Views*. Retrieved July 10, 2023, from https://www.buzzsprout.com/2148311/13142793-maritime-pilot-safety-and-reducing-the-risk-in-pilot-transfer-operations

Grant, E., Salmon, P. M., Stevens, N. J., Goode, N., & Read, G. J. (2018). Back to the future: What do accident causation models tell us about accident prediction? *Safety Science*, *104*, 99–109. https://doi.org/10.1016/j.ssci.2017.12.018

Grbić, L., Čulin, J., & Bielić, T. (2018). Inspections on board oil tankers: present situation and suggestion for improvement. *Pomorstvo*, *32*(1), 132–140. https://hrcak.srce.hr/file/296884

Gregory, K., Hobbs, A., Parke, B., Bathurst, N., Pradhan, S., & Flynn-Evans, E. (2020). An evaluation of fatigue factors in maritime pilot work scheduling. *Chronobiology International*, *37*(9–10), 1495–1501. https://doi.org/10.1080/07420528.2020.1817932

Günay, E. (2016). Evaluation of Physical and Physiological Parameters of Pilots in Terms of Professional Competence and Occupational Safety. *Journal of ETA Maritime Science.* https://jag.journalagent.com/jems/pdfs/JEMS-25743-ORIGINAL_RESEARCH_%28AR%29-GUNAY.pdf

Hall, A., Kann, M., Ferrarello, L., & Pulley, R. (2017). Encouraging Creative Risk to Reduce Risk to Life. *International Conference on Engineering and Product Design Education*. https://bura.brunel.ac.uk/bitstream/2438/15141/1/Fulltext.pdf

Han, X., Tang, T., & Lv, J. (2019). A hierarchical verification approach to verify complex safety control systems based on STAMP. *Science of Computer Programming*, *172*, 117–134. https://doi.org/10.1016/j.scico.2018.11.006

Hans Hogman History. (2023). *History of Lighthouse and Pilotage Services*. Retrieved July 02, 2023, from https://www.hhogman.se/maritime-piloting-swe.htm

Hasanspahić, N., Vujičić, S., Kristić, M., & Mandušić, M. (2022). Improving Safety Management through Analysis of Near-Miss Reports—A Tanker Ship Case Study. *Sustainability*, *14*(3). https://doi.org/10.3390/su14031094

Hignett, H. (2012). *21 Centuries of Marine Pilotage: The History of the United Kingdom Maritime Pilots' Association*. United Kingdom Maritime Pilots' Association. https://books.google.se/books?id=wGFNmwEACAAJ

Hignett, H. M. (1978). An Outline History of Marine Pilotage in Britain. *Journal of Navigation*, *31*(3). https://doi.org/10.1017/S0373463300041977

Hulme, A., Stanton, N. A., Walker, G. H., Waterson, P., & Salmon, P. M. (2019). What do applications of systems thinking accident analysis methods tell us about accident causation? A systematic review of applications between 1990 and 2018. *Safety Science*, *117*, 164–183. https://doi.org/10.1016/j.ssci.2019.04.016

Hulme, A., Stanton, N. A., Walker, G. H., Waterson, P., & Salmon, P. M. (2021). Are accident analysis methods fit for purpose? Testing the criterion-referenced concurrent validity of AcciMap, STAMP-CAST and AcciNet. *Safety Science*, *144*, 105454. https://doi.org/10.1016/j.ssci.2021.105454

ICS & IMPA. (2022). *Shipping Industry Guidance on Pilot Transfer Arrangements*. https://www.ics-shipping.org/wp-content/uploads/2022/01/Shipping-Industry-Guidance-on-Pilot-Transfer-Arrangements-v3.pdf

Igene, O. O., Johnson, C. W., & Long, J. (2022). An evaluation of the formalised AcciMap approach for accident analysis in healthcare. *Cognition, Technology & Work*, *24*(1), 161–181. https://doi.org/10.1007/s10111-021-00669-w

ILO. (2006). *Maritime Labour Convention, 2006*. International Labour Organisation. https://www.ilo.org/wcmsp5/groups/public/---ed_norm/---normes/documents/normativeinstrument/wcms_090250.pdf

IMCO. (1960). *International Convention for the Safety of Life at Sea, 1960 (with annexed Regulations)*. Intergovernmental Maritime Consultative Organization.

IMO. (1993). *Resolution A.746(18) Survey Guidelines Under The Harmonized System of Survey and Certification*. International Maritime Organization. https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/AssemblyDocuments/A.746(18).pdf

IMO. (2004). *Recommendations on Training and Certification and on Operational Procedures for Maritime Pilots Other Than Deep-Sea Pilots*. International Maritime Organization. https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/AssemblyDocuments/A.960(23).pdf

IMO. (2014). *Revised harmonized reporting procedures – Reports required under SOLAS regulations I/21 and XI-1/6, and MARPOL, articles 8 and 12*. International Maritime Organization. https://wwwcdn.imo.org/localresources/en/OurWork/MSAS/Documents/MSC-MEPC3/MSC-MEPC.3-Circ.4%20Rev%201%20%20Revised%20harmonized%20reporting%20procedures%20-%20Reports%20required%20under%20SOLAS%20regulations%20I21.pdf

IMO. (2017). *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978*. International Maritime Organization. https://www.imo.org/en/OurWork/HumanElement/Pages/STCW-Convention.aspx

IMO. (2020). *International Convention for the Safety of Life at Sea (SOLAS), 1974*. International Maritime Organization. https://www.imo.org/en/About/Conventions/Pages/International-Convention-for-the-Safety-of-Life-at-Sea-(SOLAS),-1974.aspx

IMO. (2022a). *World Maritime Theme for 2024*. International Maritime Organization. https://docs.imo.org/Shared/Download.aspx?did=142912

IMO. (2022b). *Resolution A. 1156(32) Survey Guidelines Under the Harmonized System of Survey and Certification (HSSC), 2021*. International Maritime Organization. https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/AssemblyDocuments/A.1156(32).pdf

IMO. (2023a). *Non-Governmental international Organizations which have been granted consultative status with IMO*. International Maritime Organization. https://www.imo.org/en/About/Membership/Pages/NGOsInConsultativeStatus.aspx

IMO. (2023b). *Revision of SOLAS Regulation V/23 and Associated Instruments to Improve the Safety of Pilot Transfer Arrangements Proposed Amendments to SOLAS Regulation V/23 And Resolution A.1045(27) (NCSR 10/16; Agenda Item 16)*. International Maritime Organization. https://docs.imo.org/Shared/Download.aspx?did=140912

IMO. (2023c). *IMO Docs*. International Maritime Organization. https://docs.imo.org/Category.aspx?cid=3

IMPA. (2012). *Required Boarding Arrangements for Pilot*. International Maritime Pilots' Association. Retrieved February 15, 2023, from https://pilotladdersafety.com/wp-content/uploads/2020/05/wheelhouseposter.pdf

IMPA. (2016). *IMPA Safety Survey 2016*. International Maritime Pilots' Association. https://ukmpa.org/wp-content/uploads/2017/01/impasafety-broch2016v4lo.pdf

IMPA. (2017). *IMPA Safety Survey 2017*. International Maritime Pilots' Association. https://www.scribd.com/document/662839439/IMPA-2017-Safety-Campaign-Results

IMPA. (2018). *IMPA Safety Survey 2018*. International Maritime Pilots' Association. https://www.scribd.com/document/662839355/IMPA-2018-Safety-Campaign-Results

IMPA. (2019). *IMPA Safety Survey 2019*. International Maritime Pilots' Association. https://www.bsu-bund.de/SharedDocs/pdf/DE/Unfallberichte/2020/Anhaenge/Anlage_9_4_IMPA.pdf?__blob=publicationFile&v=1

IMPA. (2020). *IMPA Safety Survey 2020*. International Maritime Pilots' Association. https://www.impahq.org/sites/default/files/content-files/impa-safety-campaign-results-2020high.pdf

IMPA. (2021). *IMPA Safety Survey 2021*. International Maritime Pilots' Association. https://www.impahq.org/sites/default/files/content-files/IMPA%20Safety%20Campaign%20Brochure%202021.pdf

IMPA. (2022). *IMPA Safety Survey 2022*. International Maritime Pilots' Association. https://www.impahq.org/sites/default/files/content-files/IMPA%202022%20Safety%20Campaign%20Results.pdf

IMPA. (2023). *About IMPA*. International Maritime Pilots' Association. Retrieved January 15, 2023, from https://www.impahq.org/about-impa

ISO. (2019). Ships and marine technology — Pilot ladders — Part 1: Design and specification (ISO 799-1:2019). *International Organization for Standardization*. https://iso.org/standard/68808.html

ISO. (2021). Ships and marine technology — Pilot ladders — Part 2: Maintenance, use, survey, and inspection (ISO 799-2:2021). *International Organization for Standardization*. https://www.iso.org/standard/74549.html

ISO. (2022). Ships and marine technology — Pilot ladders — Part 3: Attachments and associated equipment (ISO 799-3:2022). *International Organization for Standardization*. https://www.iso.org/standard/74568.html

ISPO. (2021a). *International Standard for Maritime Pilot Organizations Code*. International Standard for Pilot Organizations International Users Group https://ispo-standard.com/questions/download/89-142-3

ISPO. (2021b). *International Standard for maritime Pilot Organizations Control Manual*. International Standard for Pilot Organizations International Users Group. https://ispo-standard.com/questions/download/90-142-3

ISPO. (2023). Headlines of the standard. In *International Standard for Maritime Pilot Organizations*. International Standard for Pilot Organizations. Retrieved August 03, 2023, from https://ispo-standard.com/headlines-of-the-standard

ISPO. (2023). Newsletter, January 2023. In *International Standard for Maritime Pilot Organizations*. International Standard for Pilot Organizations International Users Group. Retrieved August 04, 2023, from https://ispo-standard.com/newsletter-january-2023

Jia, S., Wu, L., & Meng, Q. (2020). Joint Scheduling of Vessel Traffic and Pilots in Seaport Waters. *Transportation Science*, *54*(6), 1495–1515. https://doi.org/10.1287/trsc.2020.0990

Jung, M. (2021). Examining Perceptual Differences in Maritime Safety Climate: A Case Study of Korean Seafarers. *Journal of Marine Science and Engineering*, *9*(4), 381. https://doi.org/10.3390/jmse9040381

Kann, M., Hall, A., & Ferrarello, L. (2017). *Safe Ship Boarding & Thames Safest River 2030*. Royal College of Art & Lloyd's Register Foundation. https://researchonline.rca.ac.uk/2854/8/LRF%20Report%2020170613.pdf

Kitamura, K., Murai, K., Hayashi, Y., Fujita, T., & Maenaka, K. (2014). Measurement and analysis of marine pilot's performance using a large model sensor. *2014 IEEE 3rd Global Conference on Consumer Electronics (GCCE)*, 37–41. https://doi.org/10.1109/GCCE.2014.7031226

Kunnaala, V., Lappalainen, J., & Tapaninen, U. (2013). Review of pilotage processes and indicators in pilotage organisations. *WMU Journal of Maritime Affairs*, *12*(1). https://doi.org/10.1007/s13437-012-0033-2

Lai, C.-Y., Liu, C.-P., & Huang, K.-M. (2023). Optimization of the Concentrated Inspection Campaign Model to Strengthen Port State Control. *Journal of Marine Science and Engineering*, *11*(6). https://doi.org/10.3390/jmse11061166

Leveson, N. G. (2004). A new accident model for engineering safer systems. *Safety Science, 42*(4), 237–270. https://doi.org/10.1016/S0925-7535(03)00047-X

Leveson, N. G. (2009). The Need for New Paradigms in Safety Engineering. In *Safety-Critical Systems: Problems, Process and Practice* (pp. 3–20). Springer London. https://doi.org/10.1007/978-1-84882-349-5_1

Leveson, N. G. (2011). Applying systems thinking to analyze and learn from events. *Safety Science, 49*(1), 55–64. https://doi.org/10.1016/j.ssci.2009.12.021

Leveson, N. G. (2016). *Engineering a safer world: Systems thinking applied to safety*. The MIT Press. http://library.oapen.org/handle/20.500.12657/26043

Lloyd's List. (2023). *Port Directory*. Retrieved March 10, 2023, from https://directories.lloydslist.com/

MAIB. (2023). *Marine Accident Recommendations and Statistics 2022.* Marine Accident Investigation Branch. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1173305/MAIBAnnualReport2022.pdf

Main, L. C., & Chambers, T. P. (2015). Factors affecting maritime pilots' health and well-being: a systematic review. *International Maritime Health*, *66*(4). https://doi.org/10.5603/IMH.2015.0043

Marine Pilots Community. (2023). *Pilot Organisations & Pilot Companies*. Retrieved April 12, 2023, from https://www.marine-pilots.com/organisations#organisations

Meere, K., Van Damme, J., & Van Sprundel, M. (2005). Occupational injuries in Flemish pilots in Belgium. A questionnaire survey. *International Maritime Health*, *56*(1–4), 67–77. https://journals.viamedica.pl/international_maritime_health/article/view/26344

Murai, K., Hayashi, Y., Saiki, T., Higuchi, K., Fujita, T., & Maenaka, K. (2012). Evaluation of A Sea Pilot Candidate's Performance Using Small Acceleration Sensor. *Human Resource Management Research, 2012, 2(4),* 59-64. http://article.sapub.org/10.5923.j.hrmr.20120204.04.html

Murphy, L. A., Robertson, M. M., & Carayon, P. (2014). The next generation of macroergonomics: Integrating safety climate. *Accident Analysis & Prevention*, *68*, 16–24. https://doi.org/10.1016/j.aap.2013.11.011

Murray, J. M., Phillips, A. J. K., Magee, M., Sletten, T. L., Gordon, C., Lovato, N., Bei, B., Bartlett, D. J., Kennaway, D. J., Lack, L. C., Grunstein, R. R., Lockley, S. W., Rajaratnam, S. M. W., Armstrong, E., Chohan, K., Djavadkhani, Y., Dodds, K., Gunaratnam, S., Hardy, M., … Yu, K. (2019). Sleep regularity is associated with sleep-wake and circadian timing, and mediates daytime function in Delayed Sleep-Wake Phase Disorder. *Sleep Medicine*, *58*, 93–101. https://doi.org/10.1016/j.sleep.2019.03.009

Niskanen, T., Louhelainen, K., & Hirvonen, M. L. (2016). A systems thinking approach of occupational safety and health applied in the micro-, meso- and macro-levels: A Finnish survey. *Safety Science*, *82*, 212–227. https://doi.org/10.1016/j.ssci.2015.09.012

Nuutinen, M., & Norros, L. (2009). Core task analysis in accident investigation: analysis of maritime accidents in piloting situations. *Cognition, Technology & Work*, *11*(2), 129–150. https://doi.org/10.1007/s10111-007-0104-x

Okazaki, T., Muromura, M., & Kaynano, J. (2010). A study on evaluating maneuvering skill and developing support tool for marine pilot trainees berthing a ship. *2010 IEEE International Conference on Systems, Man and Cybernetics*, 3087–3093. https://doi.org/10.1109/ICSMC.2010.5641707

Oldenburg, M., Belz, L., Barbarewicz, F., Harth, V., & Jensen, H.-J. (2020). Work profile of maritime pilots in Germany. *International Maritime Health*, *71*(4), 275–277. https://journals.viamedica.pl/international_maritime_health/article/view/IMH.2020.0046/52858

Oldenburg, M., Herzog, J., Barbarewicz, F., Harth, V., & Jensen, H.-J. (2021). Online survey among maritime pilots: job-related stress and strain and the effects on their work ability. *Journal of Occupational Medicine and Toxicology*, *16*(1). https://doi.org/10.1186/s12995-021-00322-2

Palmers, A. (2020). *The IMPA Pilot Ladder Poster: Suggestions for Improvements*. International Maritime Pilots' Association. Retrieved July 13, 2023, from https://www.marine-pilots.com/articles/147387-impa-pilot-ladder-poster-suggestions-for-improvements

Paris MoU. (2023). *Inspection Results Deficiencies*. Paris MoU of Port State Control. Retrieved May 10, 2023, from https://parismou.org/Statistics%26Current-Lists/inspection-results-deficiencies

Park, Y. A., Yip, T. L., & Park, H. G. (2019a). An Analysis of Pilotage Marine Accidents in Korea. *The Asian Journal of Shipping and Logistics*, *35*(1). https://doi.org/10.1016/j.ajsl.2019.03.007

Port of London (2020). Safety Bulletin No.5 of 2020 Pilot Transfer Arrangements That Use Non-Approved Methods to Secure Pilot Ladders. *Port of London Authority*. https://pla.co.uk/assets/safetybulletin5of2020-pilottransferarrangementsthatusenon-approvedmethodstosecurepilotladders.pdf

PTR Holland. (2023a). *Magnets for pilot ladders (for clamping, positioning and holding)*. Retrieved July 27, 2023, from https://www.ptrholland.com/product/magnets-for-pilot-ladders-for-clamping-positioning-and-holding/

PTR Holland. (2023b). *Pilot ladder safety on high sided ships*. Retrieved July 27, 2023, from https://www.ptrholland.com/product/pilot-ladder-safety-on-high-sided-ships/#:~:text=The%20%E2%80%9CBlue%20Box%E2%80%9D%20suction%20pad,effective%2C%20safe%20and%20practical%20manner.

Puisa, R., Williams, S., & Vassalos, D. (2019). Towards an explanation of why onboard fires happen: The case of an engine room fire on the cruise ship "Le Boreal." *Applied Ocean Research*, *88*, 223–232. https://doi.org/10.1016/j.apor.2019.04.020

Radwanski, K., & Rutkowski, G. (2022). An Analysis of the Risks during Personnel Transfers between Units Operating on the Water. *Water (Switzerland)*, *14*(20). https://doi.org/10.3390/w14203303

Rasmussen, J. (1997). Risk management in a dynamic society: a modelling problem. *Safety Science*, *27*(2–3). https://doi.org/10.1016/S0925-7535(97)00052-0

Rhodes, W., & Gil, V. (2002). *Development of a fatigue management program for Canadian marine pilots*. Marine Safety Directorate and Transportation Development Centre of Transport Canada. https://docs2.cer-rec.gc.ca/ll-eng/llisapi.dll/fetch/2000/90464/90552/384192/620327/625023/842304/710198/A2C4W4_-_Fatigue_Management_Guide_for_Canadian_Marine_Pilots.pdf?nodeid=710463&vernum=-2

Richardson, J. C., & Godfrey, B. S. (2003). Towards ethical practice in the use of archived transcripted interviews. *International Journal of Social Research Methodology*, *6*(4), 347–355. https://doi.org/10.1080/13645570210142874

Rutledge, P. (2014). A comparison of health data from River Forth pilots in Scotland: in 1988 and 2012. *International Maritime Health*, *65*(2). https://doi.org/10.5603/IMH.2014.0010

Salmon, P. M., Cornelissen, M., & Trotter, M. J. (2012). Systems-based accident analysis methods: A comparison of Accimap, HFACS, and STAMP. *Safety Science*, *50*(4), 1158–1170. https://doi.org/10.1016/j.ssci.2011.11.009

Schröder-Hinrichs, J. U., Baldauf, M., & Ghirxi, K. T. (2011). Accident investigation reporting deficiencies related to organizational factors in machinery space fires and explosions. *Accident Analysis & Prevention*, *43*(3), 1187–1196. https://doi.org/10.1016/j.aap.2010.12.033

Schröder-Hinrichs, J.-U., Hebbar, A., Yildiz, S., Metwalli, M., & Kahlouche, N. (2023). *A pilot study of passenger ship casualties*. World Maritime University https://commons.wmu.se/lib_reports/77/

Sharma, A., & Nazir, S. (2017). Distributed Situation Awareness in pilotage operations: Implications and Challenges. *TransNav, the International Journal on Marine Navigation and Safety of Sea Transportation*, *11*(2), 103–107. https://doi.org/10.12716/1001.11.02.11

Siemieniuch, C. E., & Sinclair, M. A. (2014). Extending systems ergonomics thinking to accommodate the socio-technical issues of Systems of Systems. *Applied Ergonomics*, *45*(1), 85–98. https://doi.org/10.1016/j.apergo.2013.03.017

Sugihara, S., Hayashi, Y., Murai, K., & Ishikura, A. (2013). Investigation of Pilots' Transfer between a Vessel and a Pilot Boat at Mouths of Ise-Mikawa Bay and Osaka Bay. *The Journal of Japan Institute of Navigation*, *128*(0), 235–242. https://doi.org/10.9749/jin.128.235

Swedish Maritime Administration. (2022). *Safe Boarding Guidance on Pilot Transfer Arrangements*. Retrieved May 10, 2023, from https://sjofartsverket.se/globalassets/lotsning/lo-goteborg/safe_boarding.pdf

Symonds, N., Cunningham, B., & Hambrook, S. (2023). *Securing of pilot ladders at intermediate lengths – testing* (NCC453; 3). https://www.marine-pilots.com/file/dynamic/?token=s7YNZAX3rgtfQMh6AfaFNJlnvmmBZO8JrQFev8oc0hVV3ST2co3urh_RhaVdo7EzMv3ucdDTgaMx2eG4k6KAMQ

Teperi, A.-M., Lappalainen, J., Puro, V., & Perttula, P. (2019). Assessing artefacts of maritime safety culture—current state and prerequisites for improvement. *WMU Journal of Maritime Affairs*, *18*(1), 79–102. https://doi.org/10.1007/s13437-018-0160-5

Tokyo MoU. (2020). *Safety Bulletin 02/20 Safety of pilots boarding ships with pilot transfer arrangements that use non-approved methods to secure pilot ladders*. https://www.tokyo-mou.org/doc/P200110%20Tokyo%20MOU%20-%20SAFETY%20BULLETIN%20-%20pilot%20transfer%20arrangements%20PROOFv.pdf

Tran, T. (2003). Maritime pilotage acts of the nineteenth century. *Mariners Mirror*, *89*(1), 31–50. https://doi.org/10.1080/00253359.2003.10659272

Tunçel, A. L., Akyuz, E., & Arslan, O. (2023). Quantitative risk analysis for operational transfer processes of maritime pilots. *Maritime Policy & Management*, *50*(3). https://doi.org/10.1080/03088839.2021.2009133

Uflaz, E., Celik, E., Aydin, M., Erdem, P., Akyuz, E., Arslan, O., Kurt, R. E., & Turan, O. (2023). An extended human reliability analysing under fuzzy logic environment for ship navigation. *Australian Journal of Maritime & Ocean Affairs*, *15*(2). https://doi.org/10.1080/18366503.2022.2025687

Uğurlu, Ö., Kaptan, M., Kum, S., & Yildiz, S. (2017). Pilotage services in Turkey; key issues and ideal pilotage. *Journal of Marine Engineering & Technology*, *16*(2), 51–60. https://doi.org/10.1080/20464177.2016.1262596

UKMPA. (2023). *Safe Access – Stanchions*. United Kingdom Maritime Pilots' Association. Retrieved July 20, 2023, from https://www.portskillsandsafety.co.uk/files/2023-06/Circular-5.23-Safe-Access-Stanchions20893.pdf

Underwood, P., & Waterson, P. (2013). *Accident analysis models and methods: guidance for safety professionals*. Loughborough University: Loughborough, UK, 28. https://core.ac.uk/download/pdf/288380023.pdf

Vallance, K. (2020). *Securing pilot ladders at intermediate lengths*. Marine Pilots International Network and Community. Retrieved July 10, 2023, from https://www.marine-pilots.com/articles/14029-securing-pilot-ladders-at-intermediate-lengths

Vukić, L., Lušić, Z., Peronja, I., & Pušić, D. (2021). Overview of the Factors Affecting Compliance and Safety of Pilot Transfer Arrangements (PTA). *International Conference of Maritime Science & Technology*.

https://www.bib.irb.hr/1144177/download/1144177.NASE_MORE_2021_Conference_Proceedings_Vukic.pdf

Weigall, F. (2006). *Marine Pilot Transfers - A preliminary investigation of options (*200667474). Australian Transport Safety Bureau https://citeseerx.ist.psu.edu/document?repid=rep1&type=pdf&doi=c9f9a532844766d03f303796caea9ad77b482f14

Wróbel, K. (2021). Searching for the origins of the myth: 80% human error impact on maritime safety. *Reliability Engineering & System Safety*, *216*, 107942. https://doi.org/10.1016/j.ress.2021.107942

Wu, L., Jia, S., & Wang, S. (2020). Pilotage planning in seaports. *European Journal of Operational Research*, *287*(1). https://doi.org/10.1016/j.ejor.2020.05.009

Yan, R., & Wang, S. (2019). *Ship Inspection by Port State Control—Review of Current Research* (pp. 233–241). https://doi.org/10.1007/978-981-13-8683-1_24

Yousefi, A., & Rodriguez Hernandez, M. (2019). Using a system theory based method (STAMP) for hazard analysis in process industry. *Journal of Loss Prevention in the Process Industries*, *61*, 305–324. https://doi.org/10.1016/j.jlp.2019.06.014

Zhang, L., Wang, H., Meng, Q., & Xie, H. (2019). Ship accident consequences and contributing factors analyses using ship accident investigation reports. *Proceedings of the Institution of Mechanical Engineers, Part O: Journal of Risk and Reliability*, *233*(1), 35–47. https://doi.org/10.1177/1748006X18768917

Appendix A List of pilot transfer arrangements accident reports analysed

Accident Ref No	Name	Type	Flag	Date of Occurrence	Location of Incident	Casualty
1	Atlantic Erie	Bulk Carrier	Canada	03-11-97	Australia	Injury
2	Alexia	Bulk Carrier	Malta	04-02-04	Ireland	Injury
3	Sybille	General Cargo	Antigua	18-02-04	Ireland	Injury
4	Energy Enterprise	Bulk Carrier	USA	24-02-07	USA	Fatality
5	Emuna	General Cargo	Netherlands	05-05-07	Germany	Injury
6	Katrine Krog	General Cargo	Denmark	17-09-07	Germany	Injury
7	YM Tianjin	Container Carrier	Germany	21-07-09	Taiwan	Fatality
8	Cape Kestrel	Bulk Carrier	UK	24-07-12	South Africa	Fatality
9	Wilson Leith	General Cargo	Malta	31-05-13	UK	Injury
10	Atlantic Princess	Bulk Carrier	Greece	17-06-13	Australia	Fatality
11	Golden Concord	Chemical Tanker	Singapore	04-07-13	Australia	Injury
12	Saluzi	Passenger Ship	Malta	21-07-15	Vietnam	Fatality
13	Nord Gardenia	Tanker	Denmark	29-09-16	Denmark	Fatality
14	Sunmi	General Cargo	Bahamas	05-10-16	UK	Fatality
15	Singapore Express	Container Carrier	Hong Kong	27-02-18	Portugal	Fatality
16	Mount Olympus	Tanker	Marshal Islands	30-12-18	Russia	Fatality
17	Marfaam	Multi-Purpose Vessel	Netherlands	13-01-19	Germany	Injury
18	M/V San Diego	Bulk Carrier	Poland	19-01-19	Poland	Injury

19	Angelic Glory	Bulk Carrier	Greece	23-10-19	Singapore	Fatality
20	Unknown*	Tanker	Unknown*	28-04-20	South Africa	Injury
21	Unknown*	Unknown*	Unknown*	16-09-20	South Africa	Fatality
22	Unknown*	Unknown*	Unknown*	26-10-20	South Africa	Fatality
23	Unknown*	Unknown*	Unknown*	21-11-20	South Africa	Injury
24	Van Star	Bulk Carrier	Panama	22-04-2021	France	Injury
25	AAL Dampier	General Cargo	Cyprus	24-08-22	Australia	Injury

Note. (*) indicates that ship data within the published reports has been anonymized

Appendix B Semi-structured interview questions

Maritime pilots' semi-structured interview questions

1. Can you describe your experience as a maritime pilot, and how many years have you worked in this role?
2. Before becoming a pilot, how many years did you serve as a master or marine officer?
4. How do you assess risks associated with pilot transfer arrangements, and what criteria do you use?
5. What safety procedures do you follow during pilot transfer arrangements?
6. What challenges do you encounter when implementing these safety procedures?
7. Explain the communication protocols used during pilot transfer operations, and have you faced communication challenges during these operations?
8. Have you received specialized training on pilot transfer arrangements and safety? What resources do you rely on for safe pilot transfers?
9. What personal protective equipment is used during pilot transfer arrangements?
10. Describe the maintenance and inspection procedures for your PPE.
11. Can you discuss a recent hazardous pilot transfer operation, highlighting challenges or issues encountered?
12. Have you experienced or witnessed accidents or near misses in pilot transfer arrangements? Please share details.
13. Is there an established procedure for reporting and investigating accidents and near misses?
14. How significant are human factors in pilot transfer accidents, and how can they be mitigated?
15. Could you provide insights into your medical fitness examinations?
16. How do you stay updated on the latest regulations and best practices for pilot transfer arrangements?

Master mariners semi-structured interview questions

1. Can you share your experience as a ship's master?
2. Describe the pilot transfer arrangements on your vessel.
4. What safety measures are implemented during pilot transfer operations under your command?
5. How do you prioritize safety and ensure your crew is informed about safety protocols?
6. Discuss safety equipment or technology used on your ship for pilot transfers and its effectiveness.
7. Have you encountered accidents or near misses related to pilot transfer arrangements as a master?
8. Describe a recent incident involving pilot transfer arrangements under your command.
9. How do you ensure compliance with relevant regulations and standards for pilot transfer arrangements?
10. Explain the maintenance and inspection procedures for equipment related to pilot transfer arrangements on your ship.
11. In your opinion, what are the primary causes of accidents in pilot transfer arrangements?
12. Are you informed about pilot transfer arrangement accidents in the industry?
13. Have you and your crew received training on pilot transfer arrangements and safety?
14. Have you made improvements to pilot transfer arrangements based on incidents or pilot feedback?
15. How does your organisation prioritize safety and incident reporting for pilot transfer arrangements?

Marine chief officers and OOW semi-structured interview questions

1. Can you share your rank and years of experience as a marine officer?
2. Describe your experience with pilot transfer arrangements and safety procedures.
4. What procedures or guidelines does your crew follow for pilot transfer arrangements, and how effective are they?
5. Have you faced difficulties or challenges during pilot transfers? Please elaborate.
6. Discuss safety equipment or technology used on your ship for pilot transfers and its effectiveness.
7. Have you witnessed crew members deviating from established procedures during pilot transfers? What were the consequences?
8. Share your involvement in pilot transfer accidents or near-miss incidents, if any.
9. Explain the safety protocols in place for pilot transfer operations on your vessel.
10. How do you communicate with the pilot during transfer operations?
11. Describe your approach to managing and assessing risk in pilot transfer arrangements.
12. How frequently do you conduct risk assessments for pilot transfers?
13. In your view, what are the main factors contributing to accidents in pilot transfer arrangements?
14. Explain the maintenance and inspection plan for pilot transfer arrangements on your vessel.
15. What does your vessel's Safety Management System (SMS) say about pilot transfer arrangements?
16. Discuss the role of human factors in pilot transfer accidents and incidents.
17. Have you received training on managing and mitigating risks during pilot transfer operations?
18. Have you contributed to the development or implementation of safety procedures for pilot transfer arrangements?

Pilot boat coxswains semi-structured interview questions

1. Can you describe your experience as a pilot boat coxswain, including years in the role?
2. How do you assess risks in pilot transfer operations?
4. What safety procedures do you follow to protect the pilot during transfers?
5. Describe challenges encountered when implementing safety procedures.
6. Explain communication protocols used during pilot transfers and any related challenges.
7. Share details of your training on pilot transfer operations and safety.
8. Walk us through a recent hazardous pilot transfer operation, highlighting challenges.
9. Have you experienced or witnessed pilot transfer accidents? Describe the incidents.
10. Have near-miss incidents occurred in pilot transfers? Share details.
11. Is there a formal procedure for reporting and investigating accidents and near misses?
12. What is the compliance rate for reporting accidents and near misses in your experience?