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Artificial Intelligence (AI) in Education and Training

In an era of accelerating technological advancement, Artificial Intelligence (AI) has become an integral part of education, training and development applications. In recent years, the education and training sector has increasingly relied on AI technology, as part of the integration of modern technologies and practices to improve the overall educational experience.

AI has been able to change many aspects of teaching, learning and training processes, as it has been able to create virtual learning environments, produce smart content, create specialized plans for each student, and bridge the gaps between education, teaching and training, thus becoming one of the most effective tools in this field.

First, the term AI in education and training refers to the use of computers that operate with this technology and simulate human perception and decision-making to complete a task, in classrooms, in order to digitize the education process, and manage the educational process in the classroom and training courses. The education sector is one of the most prominent sectors that has been using AI technology for several years, with the aim of improving student learning and relieving administrative tasks that take up the time of teachers and administrators.

AI also plays a major role in changing the world of work, by automating millions of jobs (performing tasks by specific technology instead of humans), which some consider as a real threat to workers. But looking at the truth, AI should not pose a threat to humans.

On the one hand, the development of artificial intelligence leads to managing risk at work and improving some of its aspects, by using it to perform repetitive and dangerous tasks, which ensures the safety of humans.

On the other hand, AI creates new jobs and can be used as part of training solutions that rely on developing employees and improving their skills, making them more prepared for future work requirements. Based on the above, AI can be defined as “the reproduction of human intelligence in machines designed to work and think like humans.” This refers to any machine that demonstrates the characteristics of the human mind, such as the ability to learn, analyze, understand, and solve problems, perhaps more than most people realize. According to a PWC report, by 2030, AI could contribute $15.7 trillion to the global economy. 37% of companies employ AI and the need for AI experts tripled between 2015 and 2019 in IT departments.

AI has made its way into training, coinciding with the emergence of the COVID-19 pandemic. The trend of training has been implemented in all walks of life online everywhere, and trainees prefer additional resources to add value to their learning. AI makes the training system more results-oriented by helping both trainers and trainees in different ways.

Enhancing Taba Port for Efficient Maritime Connectivity in Aqaba Gulf Region

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المستخلص:
تبحث هذه الورقة البحثية في تحسين ميناء طابا لزيادة قدرته وكفاءته. تشمل التحسينات المقترحة استيعاب السفن السريعة (HSC) القادرة على نقل الركاب والسيارات والحافلات من خلال تركيب رصيف عائم ثلاثي. كما يقترح البحث مسارًا بحريًا من محطة الركاب في العقبة إلى ميناء طابا ليحل محل المسار الحالي من محطة يخوت العقبة. بالإضافة إلى ذلك، يوصي البحث باعتماد العبارات ذات النهاية المزدوجة وتنفيذ نظام النافذة الواحدة بين موانئ طابا والعقبة. يحلل البحث بيانات إحصائية على مدى سبع سنوات حول حركة البضائع والركاب، مما يبرز الانخفاض في أعداد الركاب والحاجة إلى فصل العمليات بين حركة البضائع والركاب. باستخدام تحليل نقاط القوة والضعف والفرص والتهديدات(SWOT) ، تستكشف الدراسة نقاط القوة والضعف والفرص والتهديدات لتوجيه التدخلات الاستراتيجية. تهدف هذه التحسينات إلى زيادة حركة الركاب، وتعزيز السياحة، والمساهمة في التنمية الاقتصادية للمنطقتين مع تعزيز الاستدامة والكفاءة التشغيلية.

الكلمات الرئيسية: ميناء طابا، ميناء العقبة، المسار التجريبي، رصيف عائم ثلاثي، العبارات الكهربائية ذات النهاية المزدوجة

Abstract:
This research paper investigates the enhancement of Taba Port to boost its capacity and efficiency. The proposed improvements include accommodating Hover Speed Craft (HSC) capable of transporting passengers, cars, and buses by fitting triple pontoons. A new marine route from Aqaba Passenger Terminal to Taba Port is suggested to replace the current route from Aqaba Yacht Terminal. Additionally, the adoption of double-ended ferries and the implementation of a single-window system between Taba and Aqaba ports are recommended. The paper analyzes seven years of statistical data on cargo and passenger movements, highlighting the decline in passenger numbers and the need for operational segregation between cargo and passenger traffic. Utilizing SWOT analysis, the study explores strengths, weaknesses, opportunities, and threats to inform strategic interventions. These enhancements aim to increase passenger traffic, boost tourism, and contribute to the economic development of both regions while promoting sustainability and operational efficiency.

Keywords: Taba port, Aqaba port, Pilot route, Triple pontoons, Electric double-ended ferries.

1- Introduction

Taba Port, located on the northern edge of Egypt's Sinai Peninsula, is an important link in the Gulf of Aqaba's maritime network, close to the border and just 13 kilometers south of Eilat. It serves as a key gateway for trade and tourism between Egypt and neighboring countries. The maritime corridor between Aqaba Port in Jordan and the Egyptian ports of Nuweiba and Taba is crucial for regional trade and tourism. While Aqaba Port has robust infrastructure, Taba Port faces challenges due to its compact size and limited facilities, hindering efficiency and sustainable connectivity.

Over the past seven years, data on cargo, passenger, and car movements between Aqaba and Nuweiba ports shows a decline in passenger numbers, highlighting the need for this research. Segregating cargo and trucks from passengers, cars, and buses is crucial for operational efficiency. **The aim of this research paper** is to provide insights and recommendations for enhancing Taba Port's infrastructure and capabilities to address the declining number of passengers between Jordan and Egypt and position the area as a prominent port for passenger travel and tourism in the region. **The objectives** include identifying the factors contributing to the decreasing number of passengers, assessing the current state and challenges of Taba Port, and proposing enhancements to improve passenger comfort, eco-friendliness, and maneuverability.

A SWOT analysis will be conducted to examine the strengths, weaknesses, opportunities, and threats of the Taba and Aqaba maritime system. This analysis will guide strategic interventions aimed at improving the corridor's efficiency and sustainability. The success of the maritime voyage relies on three critical factors: Taba and Aqaba ports, the navigational route, and the vessels in operation.

By focusing on these factors, the SWOT analysis will highlight the strengths and opportunities within the system. Enhancing these through infrastructure improvements, operational enhancements, and technological innovations will ensure smoother maritime operations. This paper explores potential enhancements for Taba Port, emphasizing the port's strategic geographical location, multi-modal transportation capabilities, and strong trade relations.

Opportunities identified include the potential for infrastructure upgrades, eco-friendly transportation solutions, and advancements in digital transformation technology. Specifically, the study considers accommodating Hover Speed Craft (HSC), introducing new marine routes, and implementing advanced operational systems. These enhancements aim to transform Taba Port into a more efficient and sustainable maritime transportation network, leveraging its strengths and capitalizing on emerging opportunities in the region.

2- Research Framework and Methodology.

This research addresses the decline in passenger traffic between Jordan and Egypt, caused by traffic congestion and operational challenges. The lack of efficient segregation between cargo and passenger traffic is a key factor. The focus is on enhancing Taba Port and introducing comfortable, eco-friendly, and maneuverable equipment and vessels. By improving Taba Port's infrastructure, the goal is to establish it as a leading port for passenger travel and tourism in the region.

The research purpose is to propose solutions for enhancing Taba Port to improve efficiency, promote sustainable connectivity, and foster regional economic development. By addressing challenges in passenger traffic between Jordan and Egypt, the goal is to create a smoother travel experience and boost trade and tourism. The research questions focus on the importance of Taba port regionally, the main challenges it faces, potential enhancements to overcome these challenges, and the benefits and impacts of these enhancements on the port's efficiency, sustainability, and economic development.

This study adopts a mixed-methods approach, combining qualitative and quantitative research techniques to achieve its objectives. The methodology ensures the accuracy and reliability of the findings through a structured approach. Data on cargo and passenger volumes between Aqaba, Nuweiba, and Taba Ports over the past seven years were gathered from ASEZA (2023), reports, and relevant databases. Careful criteria were applied to select data, focusing on relevance and reliability, ensuring trustworthiness.

A thorough examination of the collected information was conducted using SWOT analysis, identifying strengths, weaknesses, opportunities, and threats in the maritime transportation system. The research process was transparent, with clear documentation of data sources, selection criteria, and analysis methods, allowing others to review and replicate the research. Ethical standards were maintained, with proper citation of all data sources to uphold academic integrity, and only existing data was used for research purposes.

A case study from Aqaba port, facing similar challenges, was utilized to enrich the research. Additionally, seven years of statistical data were analyzed to provide historical context. Acknowledging limitations such as potential biases in existing data and the absence of primary data collection methods, efforts were made to address these by critically analyzing data from multiple sources. The research paper used SWOT analysis to examine cargo and passenger volumes between Aqaba, Nuweiba, and Taba Ports, employing a descriptive and analytical approach while prioritizing transparency and ethical standards. The goal was to contribute to advancements in maritime trade.

3- Taba Port Overview

Taba Port, located at the northern tip of the Gulf of Aqaba in Egypt's Sinai Peninsula, serves as a marina terminal for small passenger ferries and catamarans. Despite its size and limited infrastructure, it attracts tourists due to its scenic beauty and strategic location, acting as a key entry point for visitors from neighboring countries (Ismail, 2019).

Taba Port has a rich history, serving as a key trading terminal since ancient times, dating back to the pharaohs. Over the years, it has been renovated and expanded to support growing trade and tourism (Ismail, 2019). Managed by the Egyptian Ministry of Transport, the Taba Marine Passenger Terminal offers services for both cargo and passenger vessels. It features modern facilities, including a passenger terminal building, parking areas, and cargo-handling equipment (Brida et al., 2018).

A market analysis shows Taba's strategic Red Sea location attracts small passenger ferries. Proximity to destinations like Petra and the Sinai Peninsula boosts its appeal. Developing Taba as a homeport for small cruise ships can enhance tourism and regional economic growth. The port has the infrastructure and services needed to support cruise market growth (Brida et al., 2018).

Research by Brida et al. (2018) highlights the importance of Taba Marine Passenger Port in providing a positive visitor experience. The study suggests improvements such as increasing staff to manage passenger traffic and enhancing communication about port procedures and facilities. These changes will improve the overall service quality at Taba Marine Passenger Port (Brida et al., 2018).

4- Aqaba Passenger Terminal

The Aqaba Passenger RORO Terminal, also known as Al-Yarmouk Terminal, is vital for connecting Jordan with the Middle East and beyond. It features modern facilities, including a customs clearance area, a passenger terminal building, and parking for 500 cars, facilitating the transport of people and goods between Jordan and regional countries, especially the Gulf States (Al-Kharabsheh and Al-Qudah, 2020).

The Aqaba Passenger Terminal is favored by shipping companies for its efficient services and modern facilities. It provides a reliable and cost-effective transportation solution, handling various types of cargo, including vehicles and containers. With a capacity of up to 500,000 passengers annually, it is a key gateway for regional trade and tourism (Aqaba Development Corporation, ADC) (2023)

Case Study: Implementing Aqaba Passenger Terminal with Triple Pontoon

The Aqaba Port Authority's implementation of a triple pontoon at the passenger terminal has been successful, despite challenges. This innovative solution increased the terminal's capacity for import and export activities by allowing simultaneous docking of up to three ferries. The triple pontoon has optimized operational efficiency and streamlined processes, contributing to the terminal's growth and success (Cargotec, 2012).

5- Data and SWOT Analysis

5-1 Data of Cargo and Passengers for the Last 7 Years

Transportation analysis between Aqaba Port and Nuweiba Port from 2016 to 2022 shows fluctuating trends. Passenger numbers fell from 318,028 in 2016 to 166,946 in 2022, with car transportation also decreasing from 7,071 in 2016 to 1,905 in 2021. Truck transportation peaked at 42,341 in 2022 and hit a low of 18,816 in 2020. These trends highlight concerns about efficiency and demand. Factors influencing these trends include trade shifts and economic fluctuations, affecting transportation dynamics. The decrease raises efficiency and sustainability issues, with negative economic and environmental impacts. Recommendations include prioritizing safety, promoting environmental sustainability, and modernizing infrastructure for long-term success (Alamoush et al., 2022). The table provides a summary of passenger, car, and truck transport between Aqaba Port and Nuweiba Port from 2016 to 2022, highlighting transportation trends over this period. Source: ASEZA (2023).

Table (1) Cumulative Summary of Passenger, Car, and Truck Transport

Year	Number of Passenger	Number of Cars	Number of Trucks
2016	318028	7,071	37,173
2017	286994	5,555	35,302
2018	271092	5,649	41,672
2019	254446	4,353	41,507
2020 (Due to Corona Pandemic)	67479	390	18,816
2021	215967	1,905	27,058
2022	166946	3,914	42,341

Table (1) Cumulative Summary of Passenger, Car, and Truck Transport between Aqaba Port and Nuweiba Port (2016-2022). Source : (ASEZA. 2023)

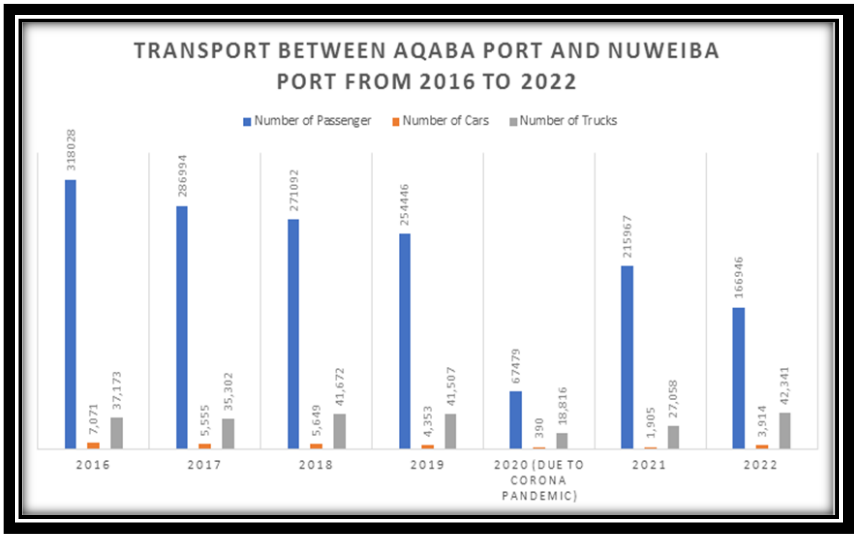

Figure (1): Transport between Aqaba Port and Nuweiba Port from 2016 to 2022. Source : (Al-Masri.H 2023)

The figure represents transport trends between Aqaba Port and Nuweiba Port from 2016 to 2022, showing numerical and percentage declines in transportation volumes. This visual aid complements the table data, helping to understand the observed trends in passenger and cargo transportation. Source: Al-Masri.H (2023).

5-2 Factors Contributing to Decreasing Passengers and Cargo

Passengers traveling between Aqaba, Nuweiba, and Taba ports face various difficulties. This section analyzes these challenges and explores factors contributing to the decline in passenger and cargo numbers over the past seven years, including issues with the ferry fleet operating between these ports effected by:

Outdated Equipment and Technology: Outdated equipment at marine terminals negatively impacts passenger experience. Older ferries require frequent maintenance, causing disruptions and higher emissions. Prioritizing safety, adopting sustainable practices, and modernizing equipment can improve transportation and promote environmental sustainability (Melnyk et al., 2021).

Delays and Congestion: Factors such as adverse weather conditions and high passenger demand contribute to delays and congestion, resulting in long waiting times and overcrowded ferries (Medeiros, 2018).

Customs and Inspection Procedures: Customs and inspection procedures at border crossings further contribute to delays and inconvenience for passengers (Medeiros, 2018).

Limited Transportation Options: Limited transportation options at marine passenger terminals can hinder passengers' accessibility to their final destinations, making it inconvenient for travelers (Sharaan et al., 2017).

Environmental Implications: The transportation sector, including marine passenger terminals, affects the environment. Emissions from ships and ferries contribute to air and water pollution and climate change (Sharaan et al., 2017).

By addressing these difficulties, prioritizing safety and comfort, adopting sustainable practices, and modernizing equipment, Aqaba, Nuweiba and Taba ports can enhance passenger experience, promote environmental sustainability, and ensure efficient flow of people and goods.

5-3 SWOT Analysis for Enhancing the Transportation System between Taba and Aqaba Ports

This section utilizes a SWOT analysis to enhance the transportation system between Taba and Aqaba Ports, based on data showing declining cargo and passenger volumes from 2016 to 2022. The analysis considers infrastructure, operations, regulations, technology, market demand, competition, and environmental sustainability. The SWOT framework, a widely accepted strategic tool, evaluates internal and external factors affecting the transportation system (Macías Párraga et al., 2019).

Identify Strengths: Explore benefits of proposed solutions for enhancing maritime connectivity.

Understand the necessity of these solutions for future development (Ceyhun, 2019).

Recognize Weaknesses: Highlight challenges in implementing the proposed solutions.

Identify areas needing improvement (Mouzakitis et al., 2022).

Uncover Opportunities: Identify potential areas for further improvement in the maritime transport system (Ceyhun, 2019).

Capitalize on emerging trends and unmet needs (Munim et al., 2021).

Acknowledge Threats: Examine external risks to the successful implementation of proposed solutions.

Address and mitigate potential obstacles proactively.

4.3.1 SWOT Analysis of the Maritime Transport System between Taba and Aqaba Ports

This SWOT analysis provides insights into factors shaping the performance of the Taba and Aqaba Ports Transportation System. By examining strengths, weaknesses, opportunities, and threats, stakeholders can enhance efficiency and sustainability. Table 2 summarizes key findings.

Table (2): SWOT Analysis of the Maritime Transport System between Taba and Aqaba Ports

Strengths	Weaknesses
Strategic geographical location.	Outdated equipment and technology
Multi-modal transportation capabilities.	Delays and congestion due to weather and high demand
Strong trade relations between Jordan and Egypt.	Limited transportation options at terminals
Digital transformations improve efficiency	Challenges in implementing digital transformations
Opportunities	**Threats**
Potential for infrastructure upgrades and technological advancements.	Environmental implications of emissions from ships and ferries.
Increasing eco-friendly transportation solutions.	Competition from alternative transportation modes.
Collaborative initiatives to streamline customs and inspections.	Political and regulatory uncertainties impacting cross-border trade.
Advancements in digital transformations technology	Digital security risks

Source: (Author. 2024)

- **Strengths:**

Multi-Modal Transportation Capabilities: Multimodal transport refers to the seamless movement of goods under a single contract but performed with at least two different modes of transport. This can include combinations of maritime, road, rail, and air transportation. The objective is to leverage the strengths of each mode to ensure efficient, cost-effective, and timely delivery of goods. The Multimodal Transport could be Achieved by: Integrated Infrastructure, Intermodal Facilities, Standardized Documentation, Coordination and Communication, Regulatory Framework (Wisetruangrot, 2020)

This enhances accessibility and flexibility in logistics operations, allowing for optimized routing and cost savings, and improving overall supply chain efficiency (ABM, 2023).

Strategic Geographical Location: Facilitates trade routes between the Red Sea and the Mediterranean (Al-Kharabsheh and Al-Qudah, 2020).

Ideal for transshipment activities and fostering regional connectivity.

Strong Trade Relations: Robust trade ties between Jordan and Egypt ensure consistent cargo flow.

Established partnerships support economic growth and regional cooperation.

Digital transformations improve efficiency: Automation of tasks and real-time analytics contribute to safety and security (Mouzakitis et al., 2022).

- **Weaknesses:**

Outdated Equipment and Technology: Outdated infrastructure and technology hinder operational efficiency and passenger experience (ABM, 2023).

Urgent upgrades needed to modernize facilities and enhance competitiveness.

Delays and Congestion: Adverse weather conditions and high passenger demand often result in delays and overcrowding at terminals (Liebreich et al., 2021).

Limited Transportation Options: Insufficient variety of transportation services at marine terminals limits passenger convenience and cargo throughput (Macías Párraga, et al., 2019).

Challenges in implementing digital transformations: Managing large datasets effectively requires substantial investment and raises ethical concerns regarding privacy (Ceyhun, 2019).

- **Opportunities:**

Infrastructure Upgrades and Technological Advancements: Modernizing terminals, equipment, and digital systems can enhance efficiency, safety, and customer satisfaction (Liebreich et al., 2021).

Eco-Friendly Transportation Solutions: Growing demand for sustainable transport options presents an opportunity to explore electric ferries and green practices (Liebreich et al., 2021).

Collaborative Initiatives with Stakeholders: Engaging customs, inspection agencies, and logistics partners in collaborative initiatives can streamline processes and improve system performance (Al-Kharabsheh and Al-Qudah, 2020).

Advancements in digital transformations technology: Technological advancements present opportunities to improve forecasting accuracy and enable real-time data collection (Munim et al., 2021).

- **Threats:**

Environmental Implications: Emissions from ships and ferries contribute to pollution, increasing regulatory pressure to adopt cleaner technologies (ABM, 2023).

Competition from Alternatives: Rival transportation modes, such as land-based routes and air transport, pose a threat to the maritime corridor's market share (Macías Párraga, et al., 2019).

Political and Regulatory Uncertainties: Geopolitical shifts and regulatory changes can disrupt cross-border trade, affecting the corridor's stability and profitability (Al-Kharabsheh and Al-Qudah, 2020).

Digital security risks: Digital security risks like cyberattacks and regulatory challenges related to compliance with evolving laws (Munim et al., 2021).

By leveraging this SWOT analysis, stakeholders can make informed decisions to enhance economic growth and promote environmental responsibility in the maritime sector (Munim et al., 2021).

6- Implementation of Voyage Key Factors

The focus is on implementing Key factors for the Taba-Aqaba maritime voyage. These include port infrastructure, navigation routes, and vessel operations. The aim is to enhance these elements to ensure efficient and sustainable transportation operations.

6-1 The feasibility of implementing pilot route.

A pilot route is a trial phase for testing a new transportation route on a smaller scale before full implementation, aiding in data collection, feasibility evaluation, and operational adjustments for success (Chou et al., 2021). While a suggested maritime route is a proposed path for maritime transportation, typically recommended based on factors like navigational safety, efficiency, and economic considerations, often involving the identification of optimal routes between ports or destinations (Entringo, 2020).

Implementing a pilot route between Taba and Aqaba ports for RORO passenger ferries is crucial for testing the feasibility of a new transportation route on a smaller scale before full implementation. The suggested maritime route aims to optimize transportation between Taba and Aqaba ports by addressing several key factors. Firstly, it offers a more direct and shorter distance, enhancing comfort for passengers. Secondly, Aqaba Passenger Terminal can accommodate cars, unlike Aqaba Marina, making the route suitable for both passengers and cars. Thirdly, maneuvering with double-ended ferries is easier, streamlining operations. Lastly, using electric ferries promotes eco-friendliness by reducing emissions. Cooperation between government entities is crucial, and monitoring passenger satisfaction and economic impact is essential for further improvements. Overall, the pilot approach enables feasibility evaluation, identifies challenges, and fosters enhanced connectivity between Taba and Aqaba ports (Liebreich et al., 2021). Changing the departure point to Aqaba Passenger Terminal reduces the trip distance from 10 NM to 6 NM, as shown in Figures (2) and (3), highlighting the route's efficiency.

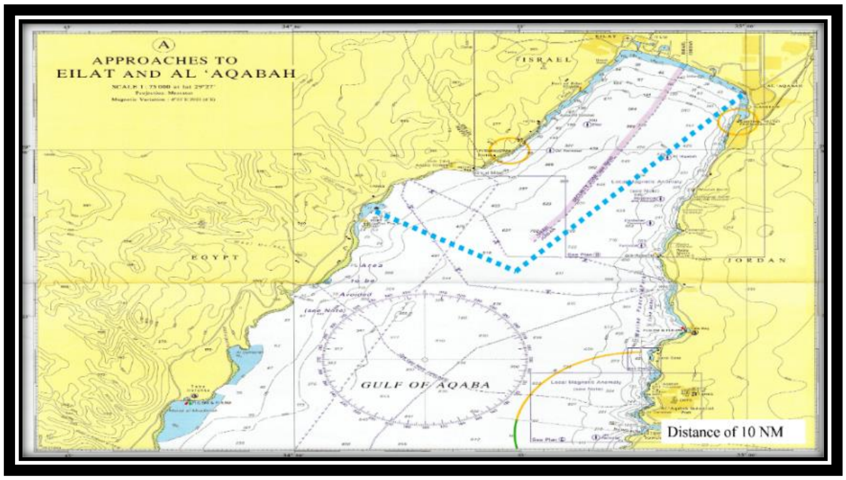

Figure (2): Route and Distance between Taba Marina Port and Aqaba Passenger Marina. Source: (Admiralty. 2021)

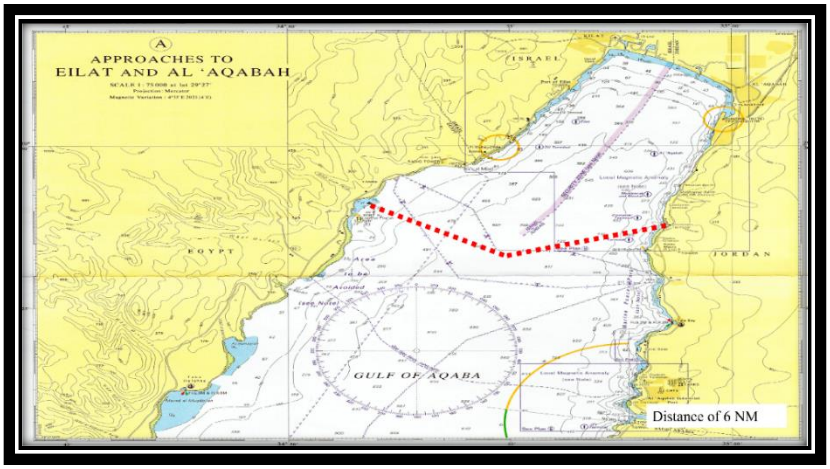

Figure (3): Suggested Route and Distance between Taba Marina Port and Aqaba Passenger terminal. Source: (Admiralty. 2021)

6-2 Infrastructure Development at Taba Port

Improve Taba Port's infrastructure to accommodate both passengers and cars, enhancing services and offering environmentally friendly transportation options. Necessary upgrades needed to enable the loading and unloading of cars alongside passenger traffic (Abdul Azim, 2017). Additionally, Cargotec designed, built, and installed a specialized floating pontoon linkspan in Aqaba Port, Jordan, facilitating RORO and passenger ferry traffic (Cargotec, 2012).

Figure (4): Triple-berth pontoon linkspan
Source: (Cargotec, 2012)

The pontoon completed in 2011 and prefabricated in Croatia, features three 25-meter-wide ferry berths and a 15-meter-wide by 26-meter-long Linkspan Bridge, accommodating three vehicle lanes and two walkway lanes. It is independent of tidal variations and ship trim, demonstrating Cargotec's engineering and supply chain management expertise. This project serves as a best practice example for developing Taba passenger terminal to handle cars and passengers simultaneously (Cargotec, 2012).

6-3 Enhancing Ferries Performance and Operations

Enhancements to the ferry services should improve maritime travel between Taba and Aqaba. This includes two-end ferries capable of accommodating cars and buses alongside passengers, aiming to enhance the overall travel experience. Additionally, the suggestion involves utilizing eco-friendly electric ferries to reduce emissions and promote environmental sustainability. These upgrades aim to optimize transportation efficiency and contribute to a greener maritime industry (Munim et al., 2021).

To conduct this proposal, the funding aspect is crucial. Given that this is a small project with high income potential, it should be a governmental project managed by the Arab Maritime Bridge Company (ABM). The ABM company was established through the cooperation of three governments: the Egyptian, Jordanian, and Iraqi governments. This governmental backing ensures that the project has the necessary support and resources to succeed. Additionally, the high-income potential of this project makes it an attractive investment, further justifying its management under a governmental framework by ABM (ABM 2023).

Conclusion and Recommendation

6-4 Conclusion

In conclusion, this research paper highlights key challenges and opportunities within the Taba and Aqaba Ports Transportation System. By addressing operational inefficiencies, infrastructure limitations, and environmental concerns, identifying areas for improvement. Enhancing port infrastructure, streamlining operational procedures, promoting intermodal transport, and segregating passenger and cargo traffic are crucial steps to optimize efficiency and sustainability. To address these challenges comprehensively recommended the implementation of pilot routes, vessel upgrades, and operational enhancements. By introducing new ferries capable of accommodating cars and buses, utilizing eco-friendly electric ferries, and improving emergency response preparedness, stakeholders can enhance the overall travel experience and promote environmental sustainability. These measures aim to transform the Taba and Aqaba Ports Transportation System into a model of efficiency, connectivity, and environmental responsibility. In summary, embracing these recommendations and fostering collaboration among stakeholders will ensure the continued growth and prosperity of the maritime corridor. This approach will contribute to economic development, enhance regional connectivity, and pave the way for a greener future.

6-5 Recommendation:

To optimize the Taba and Aqaba Ports Transportation System, stakeholders should:

1- Implement pilot routes for RORO passenger ferries between Taba and Aqaba ports.
2- Upgrade Taba Port infrastructure to accommodate cars alongside passengers.
3- Upgrade vessels to accommodate cars and buses and adopt eco-friendly electric ferries.
4- Improve operational procedures to minimize waiting times and reduce congestion.
5- Develop and update emergency response plans.
6- Encourage intermodal transport connections for improved efficiency.
7- Segregate passenger and cargo traffic to reduce congestion and emissions.

These actionable recommendations intended to guide stakeholders involved in the Taba and Aqaba Ports Transportation System. By implementing these measures, the maritime corridor can transition toward a more sustainable and efficient future while maintaining its crucial role in regional and international trade.

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Analysis of Enhancing the Competitiveness of Aden Container Terminal through Partnership with the Private Sector: A Study Using Porter's Model

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المستخلص:
برزت مشاركة القطاع الخاص في عمليات الموانئ كأستراتيجية محورية في جميع أنحاء العالم، تهدف إلى تعزيز الكفاءة، وتشجيع الاستثمار، وتعزيز القدرة التنافسية في الصناعة البحرية وفي سياق محطة عدن للحاويات، والتي تعد بوابة مهمة للتجارة والتبادل التجاري في المنطقة، فإن استكشاف مشاركة القطاع الخاص يمثل فرصًا وتحديات.

تهدف الدراسة إلى تقييم تأثير الشراكة بين القطاعين العام والخاص واثرها في تعزيز القدرة التنافسية لمحطة عدن للحاويات. بالإضافة إلى ذلك، فهي تسعى إلى تقييم الوضع الحالي، واقتراح معالجات لأوجه القصور الموجودة، وتحديد أسباب عدم الكفاءة، يمكن تصنيف هذا البحث على أنه بحث استقرائي. يهدف هذا البحث إلى تعزيز المكانة التنافسية لمحطة عدن للحاويات وتحقيق أثر الاستدامة من خلال مشاركة القطاع الخاص في أنشطة الميناء. وفي هذا السياق فقد اقتصر هذا البحث على محطة عدن للحاويات خلال العام ٢٠٢٣م؛ وقامت الدراسة على أساس استخدام تحليل Porter. خلص البحث إلى أن الشراكة مع القطاع الخاص العالمي والمتخصص في هذا الوقت تعد مسألة محفوفة بالمخاطر، نظرًا للتحديات الأمنية التي تواجهها البلاد منذ حرب صيف عام ٢٠١٥، إلى جانب عدم الاستقرار السياسي وتعطل مؤسسات الدولة التشريعية والقانونية.

الكلمات المفتاحية: الشراكة بين القطاعين العام والخاص، محطة عدن للحاويات، بورتر، اليمن.

Abstract:
Private Sector Participation (PSP) in port operations has emerged as a pivotal strategy worldwide, aimed at enhancing efficiency, promoting investment, and fostering competitiveness in the maritime industry. In the context of Aden container terminal, a crucial gateway for trade and commerce in the region, the exploration of Private Sector Participation presents both opportunities and challenges.

This study aims to evaluate the influence of Public-Private Partnerships (PPP) on bolstering the competitiveness of Aden Container Terminal. Additionally, it seeks to assess the current status, propose remedies for existing shortcomings, and pinpoint the causes of inefficiencies. This research can be classified as an inductive research approach. This research aims to enhance the

competitive position of Aden container terminal and achieving sustainability impact through participating private sector in port's activities. In this context, this research is limited to Aden container terminal for the year 2023; using Porter analysis. The research concluded that partnering with the global and specialized private sector at this time is fraught with risks, considering the security challenges the country has faced since the Summer War of 2015, along with political instability and the disruption of its legislative and legal institutions.

Keywords: Public-Private Partnerships, Aden Container Terminal, Porter, Yemen.

1- Introduction:

Sea Ports have played a crucial role in both national economic growth and international trade, as the majority of goods exchanged between nations are transported via maritime vessels (Cong, et al., 2020). Nevertheless, seaports have encountered significant competition, as evidenced by the rising number of acquisitions and mergers within the industry. (Garcia-Alonso, et al., 2019).This heightened competition is primarily driven by factors such as the increasing globalization, containerization, market integration, and the global redistribution of capital and labor. Consequently, these trends have substantially altered the governance, operation, and competitiveness of seaports, particularly container ports (Ismail, 2019).

The shipping industry has become highly competitive due to factors like intense competition, high capital requirements, and heavy reliance on global economic conditions and oil prices. This has led to three major trends in the container shipping sector (Haralambides, 2019): a growing demand for larger container vessels, the formation of container shipping alliances, and the adoption of slow steaming. Container ship sizes have notably expanded over the past two decades, with the largest containerships now reaching capacities of up to 24,000 TEUs, exemplified by vessels like the Evergreen container ship (Garrido, et al., 2020). Consequently, ports need to enhance their competitive standing by attracting these larger vessels.

Port competition has surged in recent years, shaped by various dynamic forces. Strategic planning has become crucial for survival and success, with competitiveness analysis being a key aspect of such planning. Many countries have turned to private sector partnerships to support port operations (Kang, et al., 2018), ensuring financial backing for development and enhancement initiatives, particularly in container ports. These partnerships aim to improve the efficiency and performance of container terminals, elevate their competitiveness, and ensure their sustainability.

Various types of partnerships with the private sector have emerged, tailored to the specific needs and circumstances of each country. Among these, Landlord Public-Private Partnerships (PPPs) have become widespread and extensive (Chechurina & Grin, 2020).

Many developing countries, in particular, are grappling with inefficiencies in their public service facilities and infrastructure. These inefficiencies stem from significant output losses and suboptimal labor utilization, compounded by various challenges in governmental management such as administrative complexities, a lack of technical expertise, low wages, insufficient independence, ineffective anti-corruption mechanisms, and environmental degradation due to neglectful maintenance and management practices (Tamošaitien˙e, et al., 2020).

In response to limited financial resources and a desire to streamline the state's role for optimal efficiency, many developing nations have increasingly turned to outsourcing public projects and infrastructure initiatives to the private sector. This trend has been spurred by the success stories of developed countries in establishing partnerships between the public and private sectors to deliver infrastructure services effectively (Gantman & Fedorowicz, 2020).

The rationales and incentives for partnering with the private sector can be summarized as follows:

1. Government Inefficiency: Public sector inefficiencies often lead to high costs and declining quality in service delivery, resulting in citizen dissatisfaction. Private sector participation can improve efficiency through better management, operation, and competition (Dron, et al., 2021).

2. Economic Growth and Competitiveness: Infrastructure facilities are crucial drivers of economic growth and global competitiveness. Given the substantial investments required and the limitations of state resources and administrative capacity, private sector involvement is essential for enhancing the efficiency and expansion of these facilities. (Jones & Bloomfield, 2020).

3. Financial Relief: Partnering with the private sector helps alleviate the financial burden on governments by diversifying funding sources and reducing public expenditure (Xie, et al., 2022).

4. Attracting Investments: Private sector participation attracts both domestic and foreign investments, fostering economic development and project sustainability (Haralambides, 2019).

5. Technology Transfer: Collaboration with the private sector facilitates the transfer of advanced technology and modern management practices, benefiting from the expertise of both national and foreign investors (Smith & Hensher, 2020).

6. Time and Cost Efficiency: Private sector involvement streamlines project implementation, reduces time and costs, and transfers risks to entities capable of managing them (Cherkos, et al., 2020).

7. Enhanced Operational Efficiency: Private sector flexibility allows for quicker responses to consumer needs and more agile decision-making, factors often lacking in government administration. However, this may lead to reduced government employment opportunities and potential negative impacts on tax revenue (Akopova, et al., 2020).

In summary, private sector participation in infrastructure projects offers numerous benefits, including improved efficiency, increased investment, technological advancements, and reduced financial burdens on governments.

2- Literature review:

Partnership agreements between the public and private sectors have emerged as crucial prerequisites for societal transformations due to their pivotal role in fostering local development, facilitating sophisticated project implementation, and aligning with global shifts. This issue has garnered significant attention on a global scale, as economic and social progress hinges on leveraging the collective capabilities of society, including its energies, experiences, and resources, with institutional organizations actively participating in project operation and management (Abood, 2016).

Public-private partnerships (PPPs) serve as a mechanism through which governments can procure and execute public infrastructure and services by leveraging the resources and expertise of the private sector. In situations where governments grapple with aging or insufficient infrastructure and seek more efficient service delivery, collaboration with the private sector can engender innovative solutions and provide financial support (WorldBank, 2022).

Several studies have delved into the dynamics and implications of Public-Private Partnerships (PPPs) in various sectors, including infrastructure projects and port management. These studies offer valuable insights into the effectiveness, challenges, and potential of PPPs in different contexts.

For instance, (Lopes, et al., 2021) conducted a case study on the Tibar Bay Port in Timor-Leste, focusing on assessing the performance of PPPs in the country. Through interviews and analysis of contract documents, they explored the legal framework, influencing factors, and application of PPPs in infrastructure projects. The study highlighted the readiness of the Timor-Leste government for PPP implementation but also revealed challenges regarding private sector engagement.

(Estruch, 2021) analyzed PPPs in transportation projects across the Caribbean, evaluating their adherence to good practices and benefits to the public sector. Despite improvements, issues like legal compliance and limited market engagement persist, affecting risk management and overall effectiveness. (Chechurina & Grin, 2020) examined PPPs in port management globally, emphasizing the underutilization of PPPs in Russia. They advocated for leveraging international best practices, particularly the Landlord model endorsed by organizations like the World Bank, to enhance port development in Russia.

Meanwhile, (CELIK & UMAR, 2020) explored the impact of PPPs on Nigerian seaports, specifically the APAPA Ports complex in Lagos. Their study revealed significant improvements in port efficiency and operations following the transfer of terminal management to private entities, highlighting the positive outcomes of port reforms in Nigeria.

Finally, (Malek & Gundaliya, 2020) focused on value for money (VFM) in Indian PPP road projects, identifying and evaluating VFM factors through questionnaire surveys and factor analysis. Their research aimed to enhance decision-making regarding PPP procurement by providing insights into VFM considerations.

Collectively, these studies underscore the diverse applications and implications of PPPs in infrastructure development and management, highlighting opportunities for improvement and best practices for future implementations.

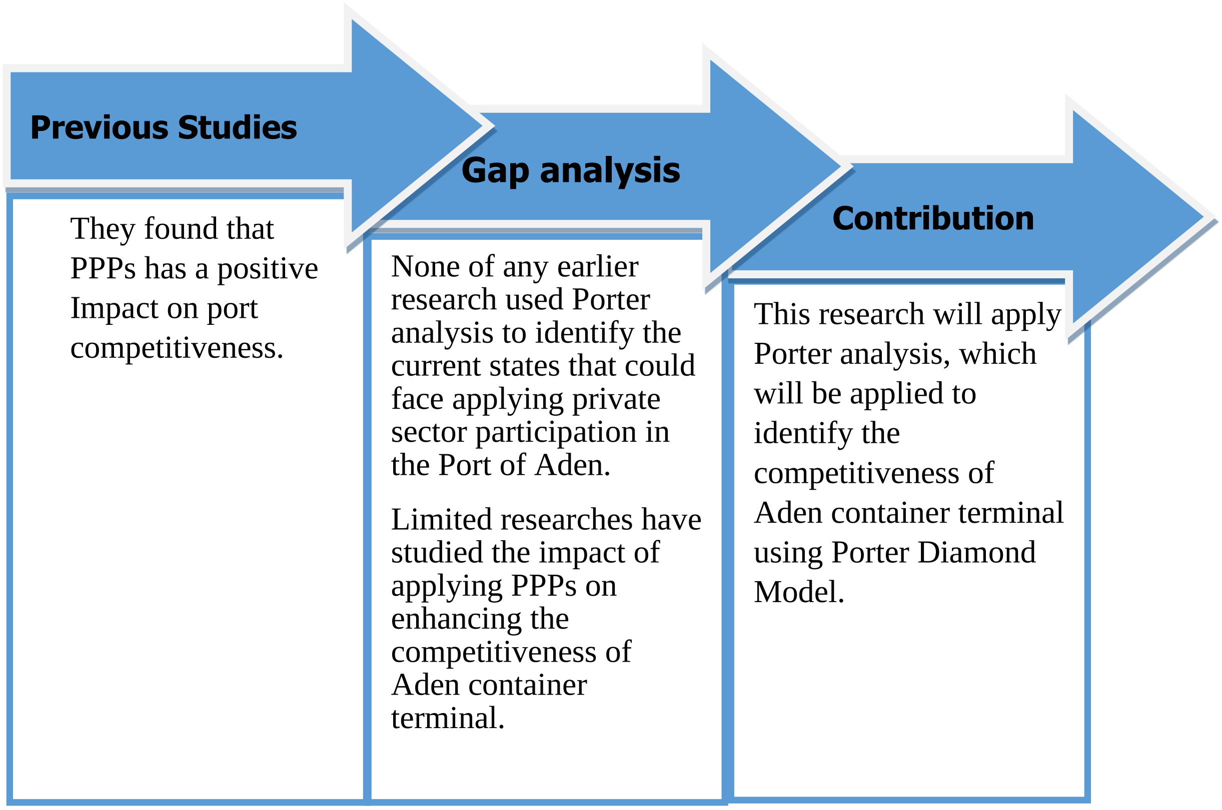

Figure (1) Research Gap Analysis and Contribution.
Reference: by author.

3- Research problem:

The establishment of the Aden Container Terminal marked a significant milestone in private sector partnerships within the maritime industry. Initially, the construction and operation of the terminal were entrusted to a private sector partnership under the Build-Operate-Transfer (BOT) model. However, this partnership was short-lived. Three years after its initiation, the initial collaboration with the private sector concluded. Subsequently, the terminal engaged in a new form of cooperation with the private sector, adopting the Landlord model for its operation and management and also has failed to continue. Hence it is necessary to investigate the reasons beyond the PPP experience failures through application of Porter analysis.

4- Research aim and objectives:

This study aims to evaluate the influence of Public-Private Partnerships (PPP) on bolstering the competitiveness of the Aden Container Terminal. Additionally, it seeks to assess the status, propose remedies for existing shortcomings, and pinpoint the causes of inefficiencies.

The findings of this research will provide valuable insights for decision-makers contemplating collaboration with the private sector, allowing them to capitalize on successful precedents from other ports. The objective of the research is to conduct a comprehensive analysis of the external and internal factors affecting the partnership project at Aden Container Terminal, taking into consideration the failures experienced in previous partnerships, despite successful models of partnership at neighboring ports.

5- Research methodology:

To bolster the competitiveness of the Aden Container Terminal, the researcher utilized Porter's Five Forces analysis to examine the factors influencing the implementation of private sector partnerships at the Port of Aden. This study follows an inductive research approach and aims to improve the competitive position of the Aden Container Terminal while achieving sustainability impact through private sector participation in port operations. This research is specifically focused on the Aden Container Terminal for the year 2023 and employs the Porter analysis tool.

6- Empirical Analysis:

Porter proposed the Diamond Model in 1990 to understand how a set of factors interact with each other to build a competitive industry or economy. The Porter Diamond Model is preferred due to its unique attributes and suitability, particularly its holistic framework for understanding the competitive advantage of nations and regions. Unlike models that focus solely on a company or industry, it examines the entire environment influencing competitiveness.

The factors determining the competitiveness of an enterprise are categorized into four main groups, as follows (Porter, 1990):

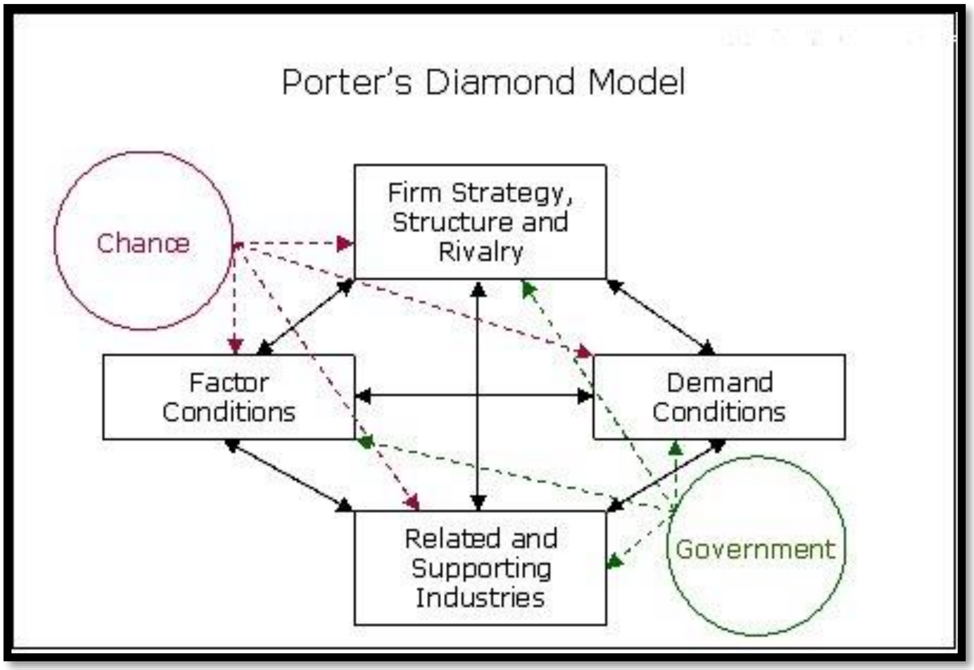

Figure (2) Michael Porter -The Competitive Advantage of Nations.
Source: (Porter, 1990)

The Porter Diamond Model illustrates how four key factors interact to drive national competitive advantage. **Firm Strategy, Structure, and Rivalry** affect and are affected by **Factor Conditions**, **Demand Conditions**, and **Related and Supporting Industries**, fostering innovation through competition. **Factor Conditions** (resources like skilled labor and infrastructure) are influenced by and influence these other factors. **Demand Conditions** (domestic market characteristics) shape and are shaped by these interactions. **Related and Supporting Industries** provide essential support, influenced by and influencing the other determinants. **Government** and **Chance** events impact all four factors, shaping the competitive landscape through policies and unforeseen events.

By applying Porter's Diamond Model at the Aden Container Terminal and conducting a comprehensive analysis based on Porter's perspective to assess the environmental factors surrounding the terminal, which influence its competitiveness and its active role in the region. We will delve into the six factors of Porter's Diamond, focusing on the Aden Container Terminal as follows:

6.1 Production Factors (Factor Conditions):

The foundation of Porter's Diamond Model encompasses production conditions, pivotal for both governmental and private entities. These conditions, intrinsic in nature, encompass the caliber of the workforce, their expertise, the availability of natural resources, and the quality of infrastructure. Porter's contention underscores the significance of advanced production conditions, emphasizing the necessity of skilled expertise and capital for gaining a competitive edge.

When examining the Aden Container Terminal through the lens of infrastructure, geographical positioning, and its accessibility to local and global markets, alongside the involvement of the private sector in its development, it can be delineated as follows:

1. The Aden Container Terminal capitalizes on its strategically advantageous location within the Port of Aden, situated near major international shipping routes. Positioned just four nautical miles from key shipping lanes, including those traversing the Gulf of Aden towards the Red Sea to the north and the Arabian Sea to the south, it holds a significant geographical advantage.
2. This prime location affords the Aden Container Terminal a competitive edge in terms of swift vessel arrivals. Rapid access to the port reduces transport time and lowers maritime trip expenses, provided that the terminal operates efficiently and meets the standards expected of competitive container terminals.
3. Despite its promising location, the Aden Container Terminal lags behind its counterparts in the Red Sea and Gulf of Aden region due to internal and external challenges. Factors such as security concerns and political instability, exacerbated by the ongoing civil conflict since 2015, contribute to its subdued performance.
4. Notably, Aden Container Terminal stands out in Yemen as the sole container terminal equipped with high-efficiency gantry cranes capable of servicing container ships. However, the prevailing security situation disrupts land routes connecting the terminal to major population centers like Taiz, Sanaa, and north Governorates, posing logistical challenges.
5. Operations at the Aden Container Terminal rely on a local workforce known for its skill and cost-effectiveness. Yet, the absence of robust training programs and qualification initiatives,

coupled with administrative issues stemming from political and security instability, hampers the optimal utilization of this valuable resource.

6. The private sector plays an active role in supporting the services of the container terminal by utilizing the latest technologies and developing and training the workforce to match the competitive ports. Consequently, the private sector has an active role in injecting funds to ensure the modernization of the infrastructure and superstructure of the container terminal. This is similarly observed in competitive container terminals in the region, represented by the ports of Salalah in Oman and Jeddah Islamic Port, which have continued development and modernization operations of both infrastructure and superstructure since the signing of partnership contracts, which subsequently reflected on the volume of activity. The table below illustrates the difference in capabilities in terms of infrastructure and superstructure of Aden Container Terminal compared to the most important ports in the research area.

Table 1. A compression between Aden container terminal and the major competitors Ports in the region.

Port	**Terminal**	**PPP Contribution**	**Capacity (Million Teu)**	**STS**	**Quay Length (meter)**	**Terminal area (ha)**	**Draught (meter)**	**RTG**	**Reefer Plugs**
Port of Salalah, Oman	Salalah Container Terminal	APM Terminals	5	21	2400	87	18		1500
Jeddah Islamic Port JIP, Saudi Arabia	South container terminal	DP World	2.4	16	1500	150	15	44	
	North container terminal	RSGT	2.4	10	1700	80	15		
	Red Sea Gateway terminal	RSGT	2.8	14	1500	70	18		
Port of Aden	Aden container terminal	Currently Owned and Operated by Government	1	6	700	45	14	8	160

Source: Websites of the research seaports.

6-2 Demand Conditions:

Demand conditions represent a cornerstone within Porter's Diamond Model, emphasizing the significance of local market demand for industry products. A surge in demand plays a pivotal role in shaping competitiveness. Porter contends that a thriving and sizable local market incentivizes producers to bolster their technological prowess and operational efficiency, thus fostering a competitive advantage at a national level. Conversely, smaller local markets characterized by sluggish economic growth rates prompt companies to seek export avenues (Sunde, 2017).

When scrutinizing the demand aspect in the context of Aden Container Terminal, several key observations emerge:

1. Since 2016, the demand for services provided by Aden Container Terminal has witnessed a notable uptick, coinciding with the civil unrest and Houthi rebels' control over the Hodeidah port. This circumstance bolstered Aden's status as the preferred choice for various stakeholders, including traders and relief organizations, seeking reliable container ship services.
2. Nevertheless, the persistent security and political turmoil within areas under the legitimate government's jurisdiction, coupled with road closures and escalated Customs duties imposed by Houthi rebels, have posed significant challenges. Consequently, many suppliers have opted for alternative shipping routes through neighboring countries, circumventing Aden altogether.
3. The reopening of Hodeidah port in early 2023 had a notable impact on Aden's container operations. Despite its rudimentary facilities, Hodeidah managed to divert a substantial portion of imported goods to Yemeni markets. However, the political agreement facilitating Hodeidah's seaport reopening failed to ensure the restoration of land routes connecting Aden to major population centers.
4. The increasing handling rate of local market shipments plays a pivotal role in the container terminal's growth, enticing shipping lines to engage in transshipment activities. However, Aden confronts obstacles such as war risk insurance mandates imposed by shipping companies, prompting the utilization of feeder ships over motherships, thereby affecting its operational dynamics.
5. Collaboration with the private sector holds promise in bolstering demand conditions by establishing direct connections between Aden container terminal and key transit ports. By enabling the direct transfer of cargo from loading ports to Aden, this partnership shortens maritime transit times, consequently reducing transportation costs. Such an advantage would position the port of Aden favorably against competing ports in neighboring countries. The resultant reduction in maritime transportation expenses would significantly enhance the port's appeal, attracting a larger share of local market imports.

6-3 Firm Strategy, Structure and Rivalry:

Competition emerges as the primary driver motivating companies within a nation to pursue a competitive edge. According to Porter, local competition prompts firms to undertake initiatives such as cost minimization, quality enhancement, and innovation. Subsequently, these firms find themselves thrust into global competition, where a nation's international competitiveness shapes the global advantage for its enterprises. The strategies and organizational structures adopted by companies wield significant influence in bolstering their competitive prowess.

The dynamic interplay between organizational structure and strategy holds a pivotal role in determining competitiveness, thereby shaping a company's overall competitive capability. Consequently, the strategies and organizational frameworks employed in managing a company or industry directly impact its performance and competitive prowess. Thus, achieving local competitiveness necessitates additional impetus for companies to transition from local to international competition. (Tasevska, 2006)

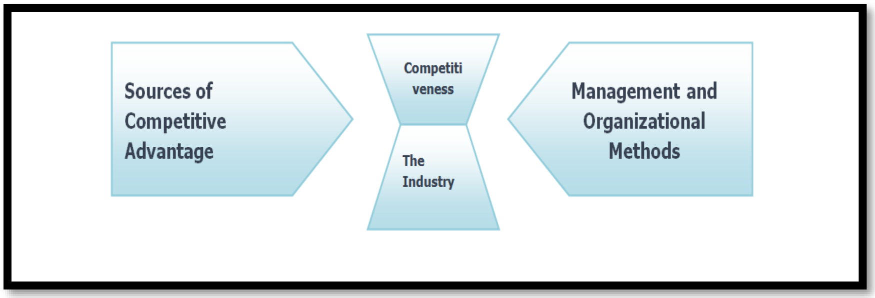

Figure (3) Industry Competitive Factors
Source: (Emzarbah, 2023)

By analyzing this factor's impact on the performance of the Aden Container Terminal, and possibility for applying the partnership with the private sectors, we can conclude the following:

1. While Aden Container Terminal benefits from an organizational structure providing some autonomy from typical public sector constraints and bureaucracy, it remains influenced by the surrounding community, impacting both performance and day-to-day operations.
2. Despite its significance within the Port of Aden, Aden Container Terminal lacks a comprehensive long-term strategic vision aimed at enhancing its competitiveness over the next twenty-five years. Currently, the terminal operates without a strategic framework guiding present operations towards future vision objectives and medium to long-term strategic plans.
3. Managed by various companies over the past two decades, Aden Container Terminal has undergone diverse management approaches, each shaped by the respective company's vision for the terminal. The table below outlines the successive management periods of Aden Container Terminal:

Table 2. Consecutive Management Periods of Aden Container Terminal

Operator	Period	Years
Singapore Port Authority - PSA	1999 - 2003	4
Overseas Port Management - OPM	2003 - 2007	4
Dubai Ports World - DP World	2008 - 2012	4
Aden Ports Development Company	2012 - 2022	10

Source: Commercial Department - Aden Container Terminal, Port of Aden

4.The table above highlights the brief tenure periods during which successive companies managed and operated Aden Container Terminal. These short intervals have disrupted the operational and developmental plans of each company, as they brought different operational and developmental visions to the table.

5.Since its establishment in 1999, Aden Container Terminal has not experienced significant investments aimed at fortifying its competitive position. This dearth of strategic investments has impeded the terminal's development, despite its advantageous location and the commencement of operations. The following table presents container terminals in the region according to their inauguration dates:

Table (2): Container terminal operation commencement date.

Port	Terminal	Start Date
Port of Aden	Aden Container Terminal	1999
Port of Salalah	Port of Salalah	1998
Port of Sohar	Oman International Container Terminal (OICT)	2007
Doraleh Port	Doraleh C T	2009
Jeddah Islamic Port	Red Sea Gate Way	2009
	North C T	2000
	South C T	1999
King Abdullah Port	King Abdulla Terminal	2013
Aqaba Port	Aqaba Container Terminal	2004
Port of Sudan	South Container Terminal	2011
Sokhna Port	Sokhna Container Terminal	2002

Source: Author from the websites of the regional container terminals

6.The absence of long-term strategic plans, coupled with an unstable security and political environment, has undermined the formulation and implementation of comprehensive development strategies for Aden Container Terminal. Furthermore, the insufficient real investments aimed at reinforcing the terminal's competitive position have impeded its ability to enhance competitiveness and redefine its position within the competitive landscape of regional ports. This is particularly concerning given the terminal's geographical and strategic significance within one of the most crucial maritime navigation corridors.

6.4 Related and Supporting Industries:

The presence of related and supporting industries alongside core industries plays a crucial role in reducing production costs. These industries create opportunities for both backward and forward linkages, thereby adding value to the enterprise's value chain. Through interconnections between industries and various market sectors, cost efficiencies are achieved through shared production facilities, technical expertise, or distribution channels (Porter, 1990).

Moreover, the proximity of related and supporting industries enables a swift response to market fluctuations and changes, facilitating quicker and easier innovations and adaptability (Singh et al., 2009). Consequently, the existence of supporting and related industries encourages collaboration, establishing a collective strength capable of confronting market challenges and fluctuations. This collaboration ensures the enhancement of local competitiveness and sustainability.

In the context of the private sector's role in Aden Container Terminal business, the following observations are noted:

1. Aden Container Terminal primarily focuses on facilitating the trade of local market imports, with exports comprising a mere 8% of its total activity (APDC, 2024). This imbalance is largely attributed to the lack of industries in the port's hinterland capable of supporting export activities, resulting in heightened transportation costs. Moreover, the country's heavy reliance on imports further exacerbates this disparity, as it lacks significant local market export goods.
2. The terminal's export activities are predominantly confined to scrap iron and plastic, destined for Southeast Asian countries for recycling and manufacturing purposes. Following the summer war in 2015, the trade in scrap exports witnessed growth due to the closure of numerous local iron factories, prompting private companies to utilize scrap materials for manufacturing.
3. Aden Container Terminal held a distinctive position in servicing containerized imports for the local market, particularly during the Hodeidah port's closure from 2015 to 2022. However, with the reopening of the Hodeidah port, a considerable portion of import activities shifted to Hodeidah due to obstacles imposed by the Houthi group, thereby impacting the competition between the two maritime ports.
4. The container terminal grapples with a deficiency in essential services such as container maintenance, cleaning, and ship and container repair workshops. These services were previously available in limited capacity due to the country's unstable security and political situation, hindering their sustained provision. Challenges in forming partnerships with the private sector persist, particularly amidst the enduring security and political instability prevailing since 2011.
5. Aden Container Terminal's involvement in re-export activities, once prominent between 1999 and 2002, has diminished significantly. During this period, containers were opened, repackaged, or reloaded, benefiting from the regulations and laws of the free zone. However, the commencement of these activities amidst security instability ultimately led to their termination.
6. The unique operational framework of Aden Container Terminal poses inherent risks, operating independently without the support of related industries to enhance its activities. Risks associated with civil war and political instability persist, potentially dissuading importers and prompting them to seek alternative shipping options to target markets more efficiently and with minimal losses.

6.5 Government:

Regarding the Aden Container Terminal, the governmental role has not significantly contributed to its competitiveness by fostering collaborative opportunities with specialized private sector entities. This could be addressed by establishing effective mechanisms, legislation, and incentivizing measures to encourage partnerships with the private sector. Such collaborations would be instrumental in enhancing the competitiveness of the port of Aden and the Container Terminal. Consequently, the following points will analyze the governmental position and its role in stimulating the private sector to enhance the competitive capabilities of the Aden Container Terminal:

1. Successive Yemeni governments have failed to enact legislation and regulatory procedures governing collaboration with the private sector, particularly concerning strategic projects like the port of Aden. Additionally, there has been a lack of review regarding previous failures in partnerships related to the management of the Aden Container Terminal since its establishment in 1999.
2. The Yemeni government has not embraced private capital nor encouraged export and re-export activities. Instead, a prolonged dispute between the port of Aden and the Free Zones Authority has persisted without resolution. Furthermore, the absence of a unified strategic plan for Aden city has led to the allocation of significant portions of adjacent areas to residential projects that do not align with the port's activities and re-export endeavors.
3. Measures to integrate the port of Aden with the local markets have not been implemented, nor have restrictions within the framework of Aden city, formerly declared as a completely free zone, been lifted. Unlike other ports such as the Islamic Port of Jeddah and the Doraleh port in Djibouti, the port of Aden lacks dedicated main roads for goods transportation, hindering supply chains and market linkage.
4. Yemeni governments have not prioritized container terminal projects or ports within their strategic plans or state budgets. These projects, if properly utilized, could significantly contribute to supporting the country's economy and providing direct and indirect employment opportunities.
5. Specific legislation for port activities or private sector investments in the maritime transport sector has not been introduced by Yemeni governments, despite container shipping representing the future of maritime transport. The absence of legislation tailored to the container terminal limits its operations, with its only benefit stemming from the Free Zone Law due to its geographical location within Free Zone areas.
6. Successive governments have also failed to study the reasons for the failure of partnerships with the private sector and to derive insights that would protect the interests of the private sector amidst satisfactory restrictions for contracting parties, ensuring partnerships based on mutual benefits and guaranteeing the development and growth of Seaports as a backbone for the country's external trade.

6.6 Chance:

The role of chance has wielded a significant impact on Aden Container Terminal, notably exemplified by the outbreak of the civil war in Yemen triggered by the Houthi rebellion in 2015. This conflict led to the closure of the Hodeidah Port, particularly as it fell under the control of Houthi rebels. As a result, all shipments were redirected to enter the Yemeni local market exclusively through Aden Container Terminal. This sudden shift resulted in a notable surge in container volumes between the latter part of 2015 and 2016, which continued thereafter.

1. The sudden surge in container numbers at Aden Container Terminal from 2016 to 2022, reaching unprecedented levels since the outbreak of war, posed challenges to terminal management's expectations for container handling and the anticipated increase in the terminal's budget and future plans.

2. Despite the increase in container numbers, the surge fell short of expectations, positioning Aden Container Terminal uniquely as the sole container terminal in Yemen capable of servicing container ships. This discrepancy is attributed to various factors, including challenges in the security situation, road safety concerns, and the efficient flow of goods to local markets.

3. Security instability in the city of Aden and its environs hindered the optimal utilization of the opportunity afforded to Aden Container Terminal to serve as a central hub for all imports and exports in the local market. Nonetheless, despite challenges posed by local competitors with land ports playing a prominent role in meeting local market demands, the container terminal achieved its highest handling rates since its establishment in 1999. This was attributed to opportunities arising during the war, with Aden Container Terminal standing out as Houthi rebels controlled the Hodeidah Port, utilizing it as a base for militia operations to disrupt stability and security.

4. The reopening of the Hodeidah Port to commercial ships has been the primary reason for the decline in container arrival rates through Aden Container Terminal, as outlined in the 2023 statistics. This decline is attributed to measures imposed by the Houthi group, including additional customs duties on imports to the local market through the Port of Aden, coupled with increased land transport costs competing with sea freight. However, the opportunity remains open, particularly given developments in the Red Sea region and Houthi threats, which may increase the use of the Port of Aden compared to the currently unsafe Hodeidah Port.

5. The classification of the Houthi group as a terrorist organization by the US administration presents an additional opportunity to circumvent dealings with seaports under Houthi control, thereby enhancing job opportunities at the Port of Aden and Aden Airport as reliable alternatives. This is particularly significant as they operate under the authority of the internationally recognized legitimate government.

6. The current opportunity for the port of Aden to serve as a primary and secure hub for container ships may also present another opportunity to attract private sector involvement in the management and development of the container terminal, and to implement plans for deepening and expanding the infrastructure. However, this also requires legislation to protect the

partnership model, which necessitates political stability, security, and a sound political system structure in Yemen, ending division, and halting the war.

7- Conclusion:

The Porter Diamond Model was used in this research paper, which is one of the most important models for analyzing the competitiveness of an enterprise or sector and its impact on the overall competitiveness of a country. The study highlights the possibility of involving the global private sector to enhance the competitiveness of the Aden Container Terminal, considering the successful experiences of partnerships with the private sector in neighboring and global ports.

Through objective analysis using the Porter Model, it was found that the Aden Container Terminal has a strategically important location, which enhanced its status and competitiveness when operations began in 1990 under the management of Singapore's PSA. However, this advantage was short-lived due to challenges faced by the country starting in 2002, including terrorist threats that led to the cancellation of partnerships and fines imposed on Yemen for failing to provide protection. Additionally, internal conflicts, culminating in the Summer War of 2015, continue to this day. Consequently, the production factors of the Aden Container Terminal were insufficient to overcome security challenges, internal conflicts, and political instability, which diminished its competitiveness, placing it at the bottom of the regional competitors' list. Currently, a partnership with the private sector is risky due to the port’s current situation amid political and security instability.

Similarly, the demand for the Aden Container Terminal’s services domestically and to meet local market needs was strong from 2015 to 2022, boosting its local standing and container handling rates, as it was the only operational container terminal. However, the situation changed with the reopening of the Hodeidah port for commercial traffic, diverting more than 50% of incoming goods to Hodeidah due to its proximity to densely populated markets and to avoid punitive measures imposed by the Houthi group on goods entering through Aden. Thus, the Aden Container Terminal is merely a local competitor seeking to attract a share of the local market imports, making it unattractive for private sector investment due to its inability to attract transit trade, given the country's security situation and high marine insurance and war risk costs.

The terminal's strategy, structure, and competitiveness have also been significantly impacted by the country's successive events. The lack of political and security stability has hindered the development of clear strategic plans for the growth and development of the Aden Container Terminal. Since 2002, various political forces with different visions and interests have dominated the political scene, impacting the strategies and policies of the Port of Aden, an integral part of the country's overall political and economic framework. The absence of supporting activities and industries and the closure of many service activities in Aden and the free zone have severely impacted export and re-export activities, raising transportation costs to the Port of Aden, which are already higher compared to neighboring ports due to the unstable security situation.

The government has never supported the port's service activities or realized the economic benefits of optimizing the use of the Port of Aden. Additionally, the state has not established specific laws and regulations for the Port of Aden to organize its operations independently and free it from bureaucratic government procedures, possibly due to the long-standing conflicts in Yemen that preoccupied decision-makers with internal struggles instead of focusing on utilizing resources efficiently to benefit the national economy and ensure resource sustainability. Moreover, there are no laws or regulations governing partnerships with the private sector, specifying the responsibilities and duties of partners, particularly in national and strategic projects like the port.

In conclusion, opportunities still exist for the Aden Container Terminal to play a better role if government support is provided to position Aden as an alternative option for shipping companies instead of the Red Sea ports, considering the security challenges posed by the Houthi group targeting commercial ships passing through the Bab al-Mandab Strait, which has led some ships to avoid the Red Sea and reroute around the Cape of Good Hope. However, a partnership with the private sector at this time is risky and may not aim to truly enhance the Port of Aden's status. Instead, such partnerships, if they occur, might be political deals without actual feasibility studies, especially given the current situation in the country suffering from the war since 2015 and its repercussions on increasing overland transport costs to Yemeni ports, including Aden, and high marine insurance premiums for ships visiting Yemeni ports.

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Ain Journal

The Role of New Technologies and Digital Transformation in Enhancing Maritime Education and Training

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المستخلص:
الغرض من هذا البحث تقييم فوائد تعزيز التعليم والتدريب البحري من خلال دمج التقنيات الجديدة والرقمية، حيث تم تطوير وتنفيذ استبيان شامل وتوزيعه على الخبراء في مجال التعليم والتدريب البحري، وتم اختيار العوامل الحاسمة والمؤثرة باستخدام تقنية التسلسل الهرمي التحليلي من بين الخصائص المشتركة التي تم تحديدها بدقة، بينما أظهرت النتائج أن العوامل والمحاور الرئيسية الثلاثة لتقييم فعالية دمج التقنيات الرقمية الجديدة في مؤسسات التعليم والتدريب البحري تأتي بأولاً البنية التحتية التكنولوجية (TI)، ثانيا جاهزية المؤسسية (RI)، التأثير التربوي (PI).

الكلمات المفتاحية:التقنيات الجديدة - التحول الرقمي - تعزيز - التعليم البحري - التدريب البحري.

Abstract
Purpose: This paper evaluates the benefits of enhancing maritime education and training through the integration of new technologies and digitalization.
Design/Methodology/Approach: A comprehensive questionnaire was developed and distributed to experts in maritime education and training; the critical factors were selected using the AHP technique from among the identified common characteristics.
Findings: The results showed that the three main decisions for evaluating the effectiveness of integrating new digital technologies into maritime education and training institutions come first (TI), second (IR), and last (PI).
Key-words: New Technologies - Digital Transformation- Enhancing- Maritime Education- Maritime Training.

1- INTRODUCTION

Amid the rapid development of technology and digitization, educational institutions are facing increasing pressures to update their curricula and teaching methods to keep pace with the digital age, The maritime education sector, being both technical and vital, is no exception to these pressures, However, maritime institutions encounter multiple challenges in effectively integrating these technologies and digitization, such as high costs, resistance to change, lack of technical skills, and inadequate infrastructure. (Honnetveit, 2015)

Maritime education has seen significant developments thanks to modern technologies, fundamentally transforming training methods and the preparation of maritime personnel. Advanced technologies such as maritime simulators, Virtual Reality (VR), and Augmented Reality (AR) have become essential tools in maritime education, allowing students to acquire practical skills in safe and interactive environments where they can experience realistic scenarios without actual risks (Gordon, 2015).

Additionally, smart systems and big data analytics play a crucial role in enhancing the efficiency of navigation and maintenance operations, thereby improving the mariners' ability to make informed decisions based on real-time data. The widespread use of technology in remote learning has also become prevalent, enabling students worldwide to access best practices and maritime knowledge without the need to be physically present at training centers. Consequently, maritime education within the context of modern technology contributes to preparing more efficient and safer maritime personnel capable of addressing contemporary challenges in the maritime industry (Rajab, 2018).

Maritime education has seen considerable improvements thanks to modern technologies, which have significantly changed the way maritime personnel are trained and prepared to face the challenges of working at sea. The increasing reliance on advanced technologies such as maritime simulators, VR, and AR has provided trainees with the opportunity to gain experience in virtual environments that mimic real-world conditions, thereby reducing risks and enhancing practical readiness. Maritime simulators offer comprehensive training experience, enabling seafarers to manage a wide range of situations, from routine operations to complex emergencies, enhancing their ability to make quick and accurate decisions (Youssef, 2000).

VR and AR technologies add an interactive dimension to training, allowing trainees to learn through immersive experiences that deepen their understanding of various scenarios and challenges they may encounter at sea. Additionally, big data analytics and smart systems contribute to providing customized training that aligns with each trainee's needs, enhancing the efficiency and effectiveness of the training process. Remote learning has also become more common thanks to e-learning platforms, enabling trainees to access advanced educational programs without the need to be physically present at specific training centers (Gordon, 2021).

By utilizing these new technologies, maritime training becomes more comprehensive and efficient, enhancing seafarers' readiness to tackle modern challenges in the maritime industry, ensuring their safety and operational effectiveness at sea (Al-Amoudi,2013).

However, despite the potential benefits of integrating new technologies and digitization in maritime education and training, maritime educational institutions often face difficulties in effectively implementing these innovations. These challenges may result in not achieving the desired improvements in efficiency and performance, thereby hindering the development of necessary skills in the maritime sector.

2- Research Hypotheses

- There is an influential relationship between enhancing maritime education and training and the integration of new technologies and digital transformation.

- There is a correlation between the integration of new technologies and digital transformation in maritime education and training and the increase in students' efficiency and performance.
- There is a correlation between the integration of new technologies and digital transformation in maritime education and training and the increase in students' satisfaction with their educational experience.

3- Study Objectives:

- Monitoring how to enhance maritime education and training through the integration of new technologies and digital transformation,
- Monitoring the improvement of students' efficiency and performance through the integration of new technologies and digital transformation in maritime education and training.
- Measuring the extent of students' satisfaction with their educational experience through the integration of new technologies and digital transformation in maritime education and training.

4- Literature Review

A- Theoretical Background

The issue of the human factor has been a significant topic of discussion in maritime transport. One of the main subjects related to the human factor in the maritime field is the competencies acquired by the ship's crew through education and training. Inadequate competencies resulting from deficiencies in education and training have clear correlations with human errors. These human errors have been cited as the primary causes of maritime accidents. In fact, 45% of the safety recommendations related to human factors in maritime accident reports were related to training, skills, and experience. Therefore, the quality of Maritime Education and Training (MET) activities directly affects the efficiency and safety of maritime transport operations (Silberg, 2017).

It is worth noting that the maritime industry is a complex socio-technical environment operating under highly variable operational, regulatory, economic, political, social, and international conditions. Maritime transport still relies on people and their expertise. Future projections indicate that the global commercial fleet, along with the need for qualified seafarers, will continue to grow. However, technological advancements and digitization have also transformed maritime transport from a labor-intensive industry into a more technical field. Some of these notable developments in maritime transport include the emergence of automation and autonomous ships, the use of advanced navigation systems, energy efficiency and emission reduction systems, hybrid and electric propulsion systems, remote monitoring and condition-based maintenance practices, and enhanced safety measures. Technologies such as improved weather forecasting, collision avoidance systems, and advanced fire suppression systems contribute to enhancing safety at sea. Most of these developments involve integrating digital tools and processes into current maritime workflows and transportation systems to improve efficiency, safety, and sustainability, this situation has also increased the need for highly trained and skilled individuals rather than unskilled labor for maritime-related roles (Jensen, 2018).

Traditionally, MET has been associated with vocational education methods for skill acquisition. This type of education emphasizes the practical capabilities of daily activities. This also means that maritime students must undergo shipboard training to gain knowledge, experience, and skills. However, onboard training is generally limited to routine and daily operations, and learning outcomes vary significantly from one ship to another. Consequently, simulation-based training and education have gained a solid footing for acquiring technical and advanced skills in MET, Initially, the primary goal of simulation training was to facilitate the development of navigation skills and aid in emergency preparedness. Today, with technological advancements, cost-effectiveness, and increased accuracy, simulators have become more readily available for a large part of the MET curriculum. This teaching method is now used alongside traditional teaching methods and has become standard in MET. Nevertheless, the use of other teaching methods or the integration of visual materials, animations, videos, and other advanced teaching tools remains very limited. One potential reason for this may be the traditional nature and strict regulations governing MET (Wahl, 2018).

The literature on MET typically refers to the education and training of seafarers, specifically focusing on the ship's crew, which includes captains, navigation officers, engineers, chief engineers, communications officers, and sailors. MET is often provided in two separate divisions (deck or engine) depending on the educational institution. Regardless, the education and competencies of the mentioned seafarers are regulated internationally according to the Standards of Training, Certification, and Watchkeeping (STCW) established by the International Maritime Organization (IMO). Training plays a crucial role in the IMO's efforts to support the implementation of international maritime standards. The STCW Code sets minimum requirements for the training of all ship crews, addressing the challenge of validating educational programs and their variability between countries by providing a unified minimum standard of competence. Revisions and amendments to the STCW Code were made in 2010, known as the "Manila Amendments". This revised version focuses on training technical and non-technical skills, as well as introducing modern teaching methods (Malalm, 2019).

Additionally, the IMO has numerous training programs, called IMO model courses, developed with contributions from various IMO members to assist in implementing STCW regulations across educational institutions. The use of simulators is well-documented and endorsed in these guidelines. Consequently, MET providers have focused on expensive, full-mission simulators to obtain high-fidelity environments, thus offering a sophisticated and established learning environment. However, exploring more personalized immersive, mobile, and accessible training opportunities such as multimedia uses, web-based and computer-based training, game-based training, and the applications of (VR) or (AR) is limited. The STCW 2010 Manila Amendments contain guidelines for e-learning processes, but they are very limited and not specific compared to the guidance and promotion provided in simulation-based training. However, as seen before the Manila Amendments, the learning environment in MET has changed again in recent years (Ortega, 2018).

Access to different technologies has become more accessible, and e-learning solutions have become part of modern society, from mobile phones to AR and VR, Game-based platforms are used not only in education but for all kinds of purposes, from marketing to business. Additionally, the maritime industry has also undergone a digital transformation. Most operational processes are now digital, and the advanced use of technology is more prevalent in the industry than ever before. This paradigm shift towards a more digital future has only accelerated when educational activities were challenged by the COVID-19 pandemic. Restrictions on face-to-face training and quarantine measures disrupted traditional maritime education. Travel restrictions and crew changes prevented students from boarding ships, and restrictions on physical training activities prevented the use of simulators in educational facilities. Suddenly, remote, or online learning became the norm. All these factors combined have made e-learning a widespread topic in many industries, and MET is one of them. This increased digitization presents an opportunity for MET to integrate various teaching technologies into training programs (Silberg, 2018).

E-learning is generally used as a complementary means to traditional learning, it is "learning supported by electronic digital tools and media, " The initial uses of the term focused on web-based tools and activities. Nowadays, it is used alongside digital learning, which consists of the use of Information and Communication Technology (ICT) in open learning and distance education. This definition includes the use of the internet, multimedia, and other immersive technologies to enhance the quality of learning. There are several forms of e-learning, and the term's use and definition can change depending on the research field. However, its popularity and applicability have significantly increased (Jensen, 2018).

Technologically enhanced learning appears to be the way forward for many industries as it offers vital advantages in motivation, engagement, time, and skill acquisition. There are clear reasons to integrate advanced learning tools into the maritime industry to move MET toward the future. E-learning can serve as a bridge between classrooms and real-life experiences. The increasing use of these learning tools in the maritime industry will open new opportunities and support the current paradigm shift we are experiencing. However, it is also crucial to determine the extent to which these tools can be integrated into MET. Therefore, this research focuses on e-learning efforts and the adoption of learning tools in maritime education. Given the growing volume of research and applications of modern learning tools, we believe a bibliometric analysis will be helpful to gain insight into the current and future state of MET (Wahl, 2018).

B- New Technologies in Maritime Education and Training

1. Virtual Reality (VR) is a technology that allows users to immerse themselves in simulated environments representing specific virtual worlds, it can be utilized across various fields including education and training, here are its uses in maritime education and training:-
   - **Maritime Training**: VR can be used to provide realistic training experiences for students in various aspects of navigation and maritime skills such as navigation, rescue operations, and maritime maintenance.

- **Interactive Learning**: With VR's ability to interact with users within the simulated environment, learning experiences can be enhanced through students' direct interaction with educational materials.
- **Safe Environment Provision**: VR can offer a safe learning environment for college students to explore dangers and situations they will come upon within the maritime environment without actual publicity to real chance.

Compared to traditional strategies, VR can provide more practical and interactive gaining knowledge of stories, helping to decorate college students' understanding and abilities within the subject of maritime education and training (Khamees, 2015).

2. Augmented Reality (AR) is a generation that combines virtual and actual elements to create a more advantageous environment based on fact, AR will have applications in maritime training and education similar to those found in Virtual Reality, together with: -
   - **Enhanced Interaction**: AR can provide interactive studies with simulated maritime elements, permitting college students to interact greater extensively with the maritime environment and benefit deeper understanding.
   - **Hands-on Training**: Using augmented academic packages, students can simulate maritime renovation operations, protection methods, and rescue operations realistically without the want for a real device.
   - **Navigation and Exploration**: Students can use augmented packages to explore the maritime environment and examine the abilities important for navigation, path making plans, and obstacle avoidance (Khamees, 2015).
3. Big Data Analytics is a present-day approach used to extract treasured patterns and insights from massive datasets, it has exciting programs in maritime schooling and training:
   - **Performance and Safety Enhancement**: By studying large information related to supply normal overall performance and maritime device, traits and functionality risks can be recognized, allowing proactive measures to decorate safety and average performance.
   - **Maritime Operations Improvement**: Big statistics analytics may be applied to enhance safety, restore operations, and maritime experience making plans, thereby increasing resource usage overall performance and lowering costs,
   - **Personalized Educational Experiences**: Using student information and analysis, educational and education testimonies may be customized to meet each scholar's man or woman wishes, enhancing studying effectiveness (Khamees, 2015).
   - **Maritime Behavior Analysis**: Ship and navigation records may be used to research maritime behavior styles and expect capacity dangers, aiding in making strategic choices to decorate safety and protection (Khamees, 2015).
4. Artificial Intelligence (AI) is an innovative technology that can revolutionize maritime education and training in several ways:-
   - **Personalized Learning**: AI can analyze scholars' conduct and academic wishes, building customized mastering models to provide a customized and effective learning level in.

- **Curriculum Development**: AI can examine overall performance data and extract developments to develop advanced curricula and deliver adaptive and appropriate academic substances.
- **Assessment Enhancement**: AI can offer smart evaluation tools that efficiently compare scholar performance and provide instantaneous remarks to useful resource improvement.
- **Simulation of Maritime Environments**: AI can be used to create realistic simulation models of maritime environments, facilitating training, and getting to know without the need for real dangers (Diop, 2018).

5. The use of robotics and automation in maritime education and training can provide numerous benefits:
   - **Student Training in Maintenance and Repair**: Robots can simulate protection and restore operations on ships and maritime systems, correctly assisting university students collect realistic skills.
   - **Safety Improvement**: Robots can fulfill hazardous responsibilities within the maritime environment, reducing the dangers related to gaining knowledge of and education aboard ships.
   - **Simulation of Maritime Conditions**: Robots can be advanced to simulate quite a few maritime conditions, supporting students in understanding the challenges they may come across whilst strolling aboard ships (Diop, 2018).

C- Expected Benefits of Integrating Modern Digital Technologies in Maritime Education

1. Enhancing Efficiency and Professional Readiness: Integrating new digital technology in maritime education can make contributions to providing an extra interactive and attractive gaining knowledge of environment for students, growing their stage of interest and interplay with the observe materials. Moreover, technology can be used to deliver multimedia educational content tailored to each student's needs effectively, enhancing the learning experience and aiding academic success.

The use of modern technologies in maritime education can also provide a practical and safe framework for training students on maritime work and navigation skills, thus equipping a new generation of well-prepared sailors and navigators to tackle future challenges in the shipping and maritime industry. Therefore, integrating new digital technologies in maritime education can achieve several advantages, including: -

- Using modern technologies such as virtual maritime simulators can reduce training costs and the time required to train students on maritime skills, for example, a study conducted by the International Maritime Organization showed that the use of maritime simulators can reduce the training time by up to 50%.
- Utilizing technologies like virtual reality to deliver realistic educational experiences encourages student participation and enhances their understanding of maritime concepts, in a study conducted by Stanford University, researchers found that using virtual reality in education can increase interaction and engagement levels by up to 80% (Rajab, 2018).

2. Increasing Interaction and Participation: Increasing interaction and participation are among the key expected benefits of integrating new digital technologies in maritime education, which include: -

- Using VR and AR technologies provides immersive educational experiences simulating real maritime environments. These technologies enable students to interact with virtual training environments that embody real-life scenarios at sea without any risk. For example, students can practice maritime maneuvers or emergency procedures in a safe environment before dealing with them in reality. According to a study conducted by PwC, the use of virtual reality in education showed an 85% increase in student interaction compared to traditional methods.
- Providing e-learning platforms offering interactive video lessons, quizzes, and forums encourages active student participation in the learning process. These platforms allow students the opportunity to review lessons, participate in group activities, and take tests that stimulate interaction. According to a study from the University of Michigan, students using interactive online educational platforms showed a 60% increase in participation rates compared to traditional education (Rajab, 2018).
- Using educational games and simulations to teach students navigation and handling of maritime equipment provides a fun and stimulating learning environment where students learn through play and interaction. According to Ed Tech Foundation, educational games increase student engagement by 70% because they make learning more enjoyable and motivating.
- Utilizing VR and AR technologies offers immersive educational experiences that replicate real maritime settings. These tools allow students to engage with virtual training environments representing authentic maritime scenarios, all without any actual risk, for instance, students can practice maritime maneuvers or emergency protocols within a safe virtual space before applying them in real-life situations. Research conducted by PwC indicates an 85% increase in student engagement when using virtual reality compared to traditional methods (Al Banna, 2019).
- Offering e-learning platforms featuring interactive video lessons, quizzes, and discussion forums encourages active student involvement in the learning journey. These platforms provide students with opportunities to revisit lessons, engage in collaborative activities, and complete assessments that promote interaction. According to a study conducted at the University of Michigan, students utilizing interactive online educational platforms demonstrated a 60% increase in participation rates compared to traditional educational approaches.
- Implementing educational games and simulations for teaching navigation skills and equipment handling in maritime contexts creates an enjoyable and stimulating learning atmosphere where students learn through interactive experiences. According to the EdTech Foundation, educational games enhance student engagement by 70% as they transform learning into a more enjoyable and motivating endeavor (Rajab, 2018).

D- Challenges in Integrating New Technologies in Education:

1.Costs and Funding: These include the following:

- Infrastructure and Equipment Costs: Marine simulators are essential tools in modern maritime education and require significant investments. Additionally, technological devices such as computers, tablets, and high-speed internet networks that support online learning and interactive applications are also needed.
- Software and Update Costs: Simulation software requires periodic updates to maintain its effectiveness and accuracy in simulating real marine conditions. Furthermore, e-learning platforms need licenses and regular testing to ensure they keep up with technological and educational advancements.
- Training for Educational Staff: Implementing modern technologies necessitates intensive training for teachers and educational staff on how to effectively use these tools. Continuous training courses are also needed to keep up with technological updates and changes (Ali, 2018).
- **Partnerships with the Private Sector**: Partnerships with technology companies and the private sector can provide financial and technical support to educational institutions, Joint funding programs and grants can help alleviate financial burdens.
- **Research and Development**: Institutions need to allocate resources for research and development to ensure the improvement and advancement of the technologies used. Collaboration with research and academic institutions can contribute to cost reduction and efficiency (Ali, 2018).

2.Administrative and Cultural Challenges: which can be summarized in the following points:

- Resistance from Employees: The introduction of new technologies often faces resistance from employees who prefer traditional methods of teaching. Additionally, there may be cultural rejection, as some institutional cultures are resistant to change, hindering the adoption of recent technology.
- Lack of Awareness and Understanding: Many educational and administrative staff may lack the necessary knowledge about the benefits and importance of new technologies, making them less receptive. There is also a shortage of qualified personnel capable of effectively implementing and managing new technologies (Ali, 2018).
- Change Leadership: Institutions need effective leadership capable of skillfully managing the change process, including providing ongoing support and guidance.

3.Infrastructure and Access to Technology Challenges: which can be summarized in the following points:

- **Lack of Equipment and Devices**: Some educational institutions may suffer from a shortage of essential technological devices such as computers, tablets, and marine simulators (Ali, 2018).
- **Internet Connectivity**: The availability of reliable high-speed internet is crucial for implementing digital education, which can be a challenge in remote or less developed areas.
- **High Costs**: Upgrading the existing infrastructure to align with modern technologies requires significant investments, posing a financial burden on educational institutions.

- **Maintenance and Updates**: Technological infrastructure requires regular maintenance and continuous updates to ensure its effectiveness, increasing long-term costs (Al - Gam,2005).
- **Digital Divide**: The digital divide can lead to unequal opportunities among students in accessing modern educational technologies, especially in less privileged areas.
- **Variable Technological Support**: There may be inconsistencies in the level of technological support available to students and teachers, affecting the quality of education.
- **Classroom Preparation**: Classrooms need to be equipped with the necessary technological tools, such as smart boards and interactive devices.
- **Necessary Infrastructure Setup**: This requires institutions to be equipped with advanced networks and stable electricity to support modern technological devices (Ali, 2018).

4. **Security and Privacy Challenges: which can be summarized in the following points:**

- **Sensitive Data**: Maritime education requires the collection and storage of sensitive personal data of students and teachers, making the protection of this data a top priority.
- **Legislation and Compliance**: Educational institutions must comply with data protection laws and regulations, such as the General Data Protection Regulation (GDPR).
- **Cyber Attacks**: There is an increasing number of cyber-attacks on educational institutions, including ransom ware and breaches, putting data and systems at risk.
- **Viruses and Malware**: Devices and networks can be affected by viruses and malware, which can disrupt operations and lead to data loss (Ali, 2018).
- **Access Control:** Strong access control systems are necessary to ensure that only authorized individuals can access sensitive information.
- **Multi-Factor Authentication**: Implementing multi-factor authentication procedures to enhance the security of system and data access (Shehata,2019).
- **Security Awareness:** A lack of awareness about the importance of cyber security among students and teachers can increase the risk of security breaches.
- **Secure Infrastructure**: Technological infrastructure must be secured against attacks, including networks, servers, and storage devices.
- **Security Updates**: Regularly applying security updates is essential to protect systems from discovered vulnerabilities (Ali, 2018).

5- RESEARCH METHODOLOGY

Based on a literature review and discussions with experts, the descriptive-analytical method was adopted as the most suitable scientific approach for collecting field data on this phenomenon using a field questionnaire. A comprehensive questionnaire was developed and distributed to a group of students, totaling fifty, who were selected through purposive sampling to understand their characteristics, attitudes, thoughts, and uses regarding the study topic.

The retrieved questionnaires were examined, and the most common criteria were identified and agreed upon. Subsequently, the critical factors were selected using the Analytic Hierarchy Process (AHP) technique from those common attributes. AHP is an analytical method used for decision-making in multi-dimensional and complex scenarios. In this context, it is employed to select critical factors or key factors to be focused on in the study or research. This allows researchers to prioritize various factors based on the opinions of experts or study participants. This is done by evaluating the relative importance of each factor compared to others and determining which factors have higher priority. Using AHP, researchers identify the main critical factors that will significantly impact the quality of maritime learning and should be emphasized in the current study.

To illustrate the process of selecting factors, criteria, and alternatives in the research using AHP, Figure (1) shows the hierarchical diagram of the Analytic Hierarchy Process, this diagram consists of the following levels: -

- **Main Objective**: Enhancing maritime education and training through the integration of new technologies and digital transformation.
- Criteria: The most common and agreed-upon criteria.
- Critical Factors: The factors identified using AHP significantly impact the achievement of the main objective.

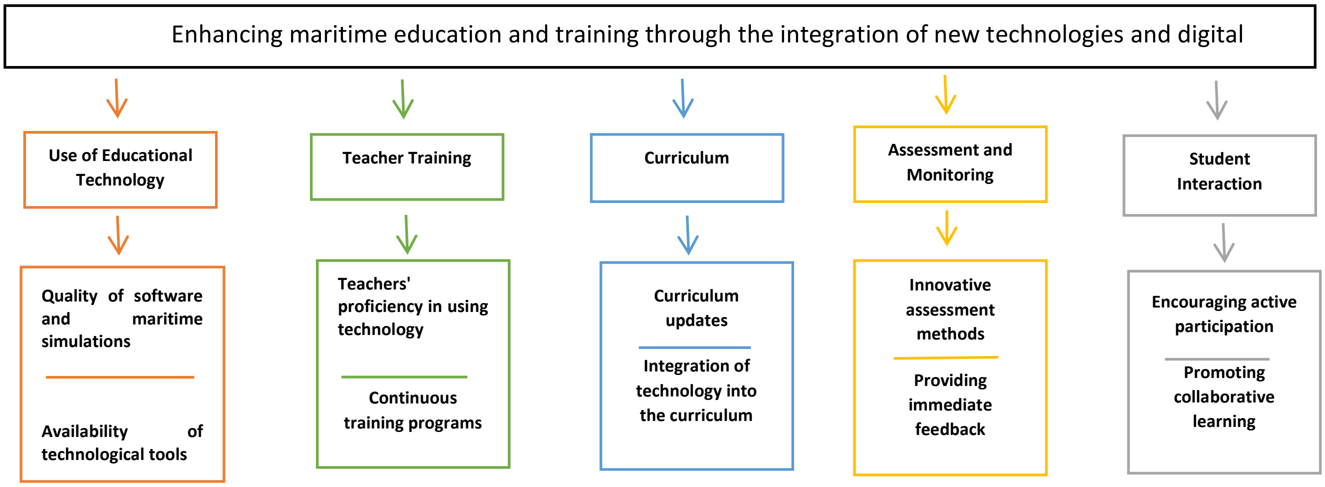


Figure (1): Hierarchical Diagram of the Analytic Hierarchy Process (AHP)

The AHP was chosen as an analytical tool used in various fields such as business management, engineering, social sciences, medicine, and others. This method was originally developed by the American scholar Thomas L, Saaty in the 1970s. AHP relies on the technique of pairwise comparison, where the question "Which is more important: factor (A) or factor (B)?" is posed to determine priorities among different factors. AHP is distinguished by its ability to handle complexity and provide systematic solutions to multi-dimensional and intricate decision problems. Analysts use AHP to set priorities and provide a comprehensive assessment of the factors influencing decisions, whether these factors are related to setting strategic goals, project planning, or making daily operational decisions. AHP applies the idea of pairwise comparison along with a hierarchical structure or network analysis to choose the optimal option from a list of possible choices. The main objective of the AHP method is to select an alternative from a list of options that best meets a specific set of criteria, or to calculate the weight of the criteria in any application by utilizing the decision maker's or expert's experience or knowledge in a pairwise comparison matrix of attributes.

The AHP methodology uses a natural, pair-wise mode to compare criteria or alternatives in relation to a criterion. The three parts of the AHP approach are: (1) identifying obstacles and designing a hierarchy prioritizing model) (2) (creating a questionnaire and gathering data, and (3)figuring out normalized weights for each category of barriers and each individual barrier.

6- DATA ANALYSIS

"In this section, it will be demonstrated how the AHP can be utilized to assess the effectiveness of integrating new digital technologies in maritime education and training institutions. Application of AHP to Evaluate the Integration of New Digital Technologies. Three primary criteria for assessing the effectiveness of integrating new digital technologies in maritime education and training institutions will be considered, which are: (1) Pedagogical Impact (PI); (2) Technological Infrastructure (TI); and (3) Institutional Readiness (IR) .

A recognized pairwise comparison matrix of the effectiveness of integrating new digital technologies in maritime education and training institutions, provided by one of the specialists involved in the investigation, is depicted in Table 1, Pedagogical impact is assigned the highest weight, followed by technological infrastructure, and institutional readiness.

Table (1): Pairwise Comparison Matrix for Evaluating the Effectiveness of Integrating New Digital Technologies in Maritime Education and Training Institutions,

Challenges	PI	TI	IR	CW	GM	W	WSV
PI	1	1	0, 5	1, 83	1, 83	9, 56%	**1, 83**
TI	3, 45	0, 56	1	2, 71	2, 71	22, 9%	**2, 71**
IR	3, 21	0, 89	0, 5	2, 46	2, 46	36, 8%	**2, 46**
SUM	7, 66	2, 45	2	-	7	1	

CW = Σ PI + TI + IR / 3

Then, ʎ max, Consistency Index (CI) and Consistency Ratio (CR) are determined by summing the results of multiplying the pair wise comparison's overall value by each of the system's weights.

ʎ MAX = Σ (WSC n / CW n)

ʎ Max= = λ max= (1, 831+2, 713, 45+2, 463, 21+27, 66)/3=2, 318

CI = ʎ MAX / total of criteria – 1 CI= 2, 318/ 3-1 = -0, 22733 CR = CI / -0, 22733

For validation CR = 0, 078546 (CR < 0, 1 valid)

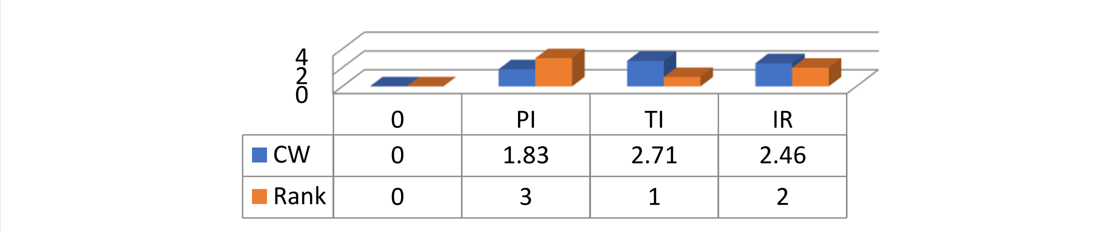
The pair wise determination is declared valid with this CR value when the CR value is less than 0, 1, Table 1 values are acceptable and consistent because CR is less than 0, 1,

The pair wise compression matrix's consistency is verified before the decision matrix is obtained as follows:

Table (2): Decision Matrix for Main three Evaluating the Effectiveness of Integrating New Digital Technologies in Maritime Education and Training Institutions

Criterion	CW	Rank
PI	1, 83	**3**
TI	2, 71	**1**
IR	2, 46	**2**

According to Table 2, it can be observed that the three main decisions for evaluating the effectiveness of integrating new digital technologies into maritime education and training institutions come first (TI), second (IR), and last (PI),



Fig, 2, Decision Matrix for Main three Evaluating the Effectiveness of Integrating New Digital Technologies in Maritime Education and Training Institutions, According to Table 2

1. Results of the first hypothesis test: There is an influential relationship between enhancing maritime education and training, integrating new technologies, and digital transformation,

Table (3): Decision Matrix for Evaluating the Effectiveness of Integrating New Digital Technologies in Maritime Education and Training Institutions

Dependent Variable	Independent Variable	Correlation Coefficient (R)	Coefficient of Determination (R²)	Significance Level
Integrating new technologies and digital transformation	Enhancing maritime education and training	0, 559	0, 313	0, 00)(Statistically significant

It is evident from Table 3, which shows the influential relationship between enhancing maritime education and training, integrating new technologies, and digital transformation using the statistical test (Simple Regression Analysis), that: There is a significant relationship between enhancing maritime education and training and integrating new technologies and digital transformation, with a strong correlation coefficient of 0, 559 at a significance level of 0, 00, which is statistically significant. The effect size is 0, 313, indicating that 31% of the variations in maritime education and training are explained by the integration of new technologies and digital transformation. This means that the newer technologies and digital transformation are integrated, the more they enhance maritime education and training. From the above, the hypothesis that there is an influential relationship between enhancing maritime education and training and integrating new technologies and digital transformation is confirmed.

2. Results of the second hypothesis test: There is a correlation between integrating new technologies and digital transformation in maritime education and training and increasing students' efficiency and performance.

Table (4): Decision Matrix for Evaluating the Effectiveness of Integrating New Digital Technologies in Maritime Education and Training Institutions

Integrating new technologies and digital transformation in maritime education and training	**Increasing students' efficiency and performance**
Pearson Correlation Coefficient	Significance Level
0, 939	(0, 00)

It is evident from Table 4, using the Pearson correlation coefficient that: There is a strong positive correlation between integrating new technologies and digital transformation in maritime education and training and increasing students' efficiency and performance, with a Pearson coefficient of 0, 939 at a significance level of 0, 00, which is statistically significant. This means that the more capable the integration of new technologies and digital transformation in maritime education and training, the more it affects the increase in students' efficiency and performance, whether positively, negatively, or both. From the above, the hypothesis that there is a correlation between integrating new technologies and digital transformation in maritime education and training and increasing students' efficiency and performance is confirmed.

Results of the third hypothesis test: "There is a correlation between integrating new technologies and digital transformation in maritime education and training and increasing students' satisfaction with their educational experience".

3. Results of the third hypothesis test: "

Table (5): Decision Matrix for Evaluating the Effectiveness of Integrating New Digital Technologies in Maritime Education and Training Institutions

Increasing students' satisfaction with their educational experience	Integrating new technologies and digital transformation in maritime education and training
Pearson Correlation Coefficient	Significance Level
0, 918	(0, 00)

It is evident from Table 5, using the Pearson correlation coefficient that:

There is a strong positive correlation between integrating new technologies and digital. transformation in maritime education and training and increasing students' satisfaction with their educational experience, with a Pearson coefficient of 0, 918 at a significance level of 0, 00, which is statistically significant. This means that the more capable the integration of new technologies and digital transformation in maritime education and training, the more it affects the increase in students' satisfaction with their educational experience, whether positively, negatively, or both.

From the above, the hypothesis that there is a correlation between integrating new technologies and digital transformation in maritime education and training and increasing students' satisfaction with their educational experience is confirmed.

7- CONCLUSION AND DISCUSSION

In conclusion, it can be confidently stated that integrating new and digital technologies into maritime educational institutions is a crucial step towards enhancing the quality of education and training in this field. By leveraging modern technology, institutions can provide an advanced and comprehensive learning environment that helps equip students with the necessary skills to tackle the challenges of the modern era.

Additionally, this integration contributes to enhancing student interaction and effective participation in the learning process, ultimately leading to distinguished and qualified professionals for the global maritime job market. However, institutions must continue to monitor the implementation of these technologies and regularly evaluate their effectiveness to ensure the ongoing improvement of maritime education and training in the future.

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Assessing the Impact of Implementing Green Sustainability Practices in Ports on Environmental and Economic Performance

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المستخلص:
الهدف من هذه الورقة هو تقييم فوائد اعتماد الممارسات الخضراء في إدارة الموانئ، مع التركيز على مساهمتها في الاستدامة البيئية والاقتصادية. من خلال تعزيز الأساليب الواعية بيئيًا، يمكن للموانئ تقليل بصمتها البيئية وأيضًا تحسين كفاءتها التشغيلية، مما يخلق توازنًا بين الأهداف البيئية والاقتصادية.

تم استخدام نهج منهجي لجمع وتحليل البيانات ذات الصلة. تم تصميم استبيان شامل وتوزيعه على خبراء متخصصين في إدارة الموانئ المستدامة لتحديد العوامل الأكثر تأثيرًا في التنفيذ الناجح، تم تطبيق عملية التحليل الهرمي(AHP) مع التركيز على الخصائص الرئيسية المرتبطة عادةً بعمليات الموانئ المستدامة.

نتائج الدراسة توضح أولوية واضحة لعوامل رئيسية في تقييم تأثير الممارسات الخضراء داخل الموانئ. البنية التحتية التكنولوجية ظهرت كأهم عامل، نظرًا لدورها في تمكين الابتكارات المستدامة وعمليات الموانئ الفعالة. ثم، جاهزية المؤسسات في المرتبة الثانية، مع التأكيد على ضرورة وجود سياسات داعمة وثقافة تنظيمية ملتزمة. وأخيرًا، تم اعتبار التأثير البيئي، مع تسليط الضوء على أهمية متابعة والتخفيف من الآثار البيئية كجزء من تبني الممارسات الخضراء.

هذه الأفكار تبرز ضرورة وجود نهج شامل، يدمج بين التكنولوجيا، جاهزية السياسات، ومراقبة البيئة لتحقيق أهداف التنمية المستدامة.

الكلمات المفتاحية: الاستدامة البيئية - الممارسات الخضراء - الموانئ - البنية التحتية التكنولوجية.

Abstract:
The purpose of this paper is to evaluate the benefits of adopting green practices in port management, specifically examining their contribution to environmental and economic sustainability. By promoting environmentally conscious approaches, ports can not only reduce their environmental footprint but also enhance their operational efficiency, and creating a balance between environmental and economic goals.

It employed a systematic approach to collecting and analyzing relevant data. A comprehensive questionnaire was designed and distributed to experts specializing in sustainable port management. To identify the most influential factors for successful implementation, the Analytic Hierarchy Process (AHP) was applied, focusing on key characteristics commonly associated with sustainable port operations.

The findings of this study reveal a clear prioritization of key factors in evaluating the impact of green practices within ports. Technological infrastructure emerged as the most important factor, given its role in enabling sustainable innovations and efficient port operations. This is followed by institutional readiness, emphasizing the need for supportive policies and a committed organizational culture. Finally, environmental impact was considered, highlighting the importance of monitoring and mitigating environmental effects as part of adopting green practices. These insights underscore the necessity of a comprehensive approach, integrating technology, policy readiness, and environmental monitoring to achieve sustainable development goals.

Keywords: Environmental Sustainability - Green Practices - Ports - Technological Infrastructure

1- INTRODUCTION

In the face of rapid technological advancements and digitalization, ports are under increasing pressure to modernize their operations and adopt more sustainable practices to protect the environment and achieve economic development. Green ports are a crucial part of these efforts, playing a key role in reducing the environmental impact of the maritime industry. However, ports face multiple challenges in effectively implementing their green initiatives, such as the high cost of eco-friendly technology, resistance to change, lack of technical expertise, and insufficient infrastructure necessary for these updates.

Green ports have seen significant improvements, leading to essential changes in the management of maritime operations and the reduction of harmful emissions. Technologies such as renewable energy systems, process automation, and big data analytics have become vital tools in achieving environmental sustainability in ports, enabling substantial enhancements in operational efficiency and reducing the environmental impact of maritime activities.

Additionally, smart systems and data analytics contribute to improving the financial efficiency of ports by enhancing resource management and reducing operational costs. These technologies have also become a key element in improving the ability to make informed decisions based on real-time data. The spread of technology in port operations has also facilitated the adoption of best practices on an international scale, contributing to the enhancement of efficiency and sustainability in maritime operations.

By leveraging these modern technologies, ports have become more capable of effectively addressing contemporary environmental and economic challenges, contributing to the achievement of sustainable development goals and ensuring the long-term sustainability of maritime operations.

However, despite the potential benefits of adopting new technologies and digitalization in green ports, they often face difficulties in effectively implementing these innovations. These challenges may result in a failure to achieve the desired improvements in efficiency and performance, hindering the development of the essential capacities needed to enhance sustainability in this sector.

2- Study Objectives:

- To examine how environmental and economic sustainability can be enhanced through the implementation of green practices in ports.
- To assess improvements in operational and economic efficiency through the application of renewable energy technologies and automation in ports.
- To measure the level of satisfaction among employees and beneficiaries regarding their experience in green ports through the adoption of digital transformation.

3- Research Hypotheses

- There is a strong relationship between improving green port operations and
- There is a correlation between the adoption of digital transformation in green ports and the increase in satisfaction among port personnel and service beneficiaries.

4- LITERATURE REVIEW

4-1 Theoretical Background "Green Ports: Definition and Concept"

- **Definition of Green Ports:** Green ports are those that adopt practices aimed at reducing harmful emissions, enhancing the efficiency of natural resource utilization, and minimizing waste and byproducts from port operations. These ports focus on using environmentally friendly technologies such as renewable energy, organic water treatment, and advanced waste management systems. The goal of these ports is to serve as models for how to reduce environmental impact while maintaining economic performance and competitiveness (Ortega-Sanchez et al., 2018).
- **The Concept of Green Ports:** The concept of green ports relies on a set of environmental principles based on developing technologies and operational methods that contribute to reducing the negative environmental effects of port activities (Munino et al., 2018). This concept can be divided into several key components:

- **Emission Management:** Green ports' efforts include reducing carbon dioxide emissions and other pollutants through the use of renewable energy sources, such as solar and wind power, and adopting clean fuel technologies (Bergillos et al., 2018).
- **Waste Management:** Green ports strive to improve waste management through recycling practices, safe handling of hazardous waste, and reducing waste generated from port operations (Magana et al., 2018).
- **Energy Efficiency Improvement:** This involves reducing energy consumption by improving operational efficiency and using modern technologies such as smart lighting systems and more efficient electrical equipment (Clavero et al., 2018).
- **Natural Resource Conservation:** Green ports aim to reduce the use of natural resources such as water and land by adopting water conservation technologies and managing land sustainably (Diez-Minguito et al., 2018).
- **Collaboration with the Local Community:** Green ports are committed to collaborating with local communities to promote sustainable development and achieve mutual environmental and economic benefits (Paquiero et al., 2018).

- **Environmental Innovations in Green Ports:** Green ports depend on several environmental innovations that help enhance overall environmental performance, including the use of smart transportation systems to reduce traffic congestion and related emissions, and the application of strict standards for monitoring and evaluating environmental performance (Ortega-Sanchez et al., 2018).

4-2 The Role of Green Ports in Enhancing Environmental and Economic Sustainability

- **Technologies Used in Green Ports:** Green ports rely on modern and innovative technologies to achieve sustainability goals. These technologies include the use of renewable energy sources such as solar and wind power to operate port systems and facilities. Sustainable heating and cooling technologies are also employed to reduce energy consumption. Additionally, water treatment and reuse technologies are used in cleaning and maintenance processes, reducing the consumption of fresh water and minimizing pollution from contaminated discharges (Bergillos et al., 2018).
- **Waste Management and Reducing Environmental Impact:** Waste management plays a crucial role in achieving environmental sustainability in green ports. Strict waste management practices are adopted, including reducing the amount of waste generated, recycling, and using organic decomposition methods for organic waste. Hazardous waste is handled safely in accordance with international environmental standards. These measures help to minimize the environmental impact of port activities and enhance the protection of the surrounding environment (Magana et al., 2018).
- **Reducing Carbon Emissions:** Ports are significant sources of carbon emissions due to ship traffic and heavy equipment operations. To mitigate these emissions, green ports utilize advanced technologies such as clean fuels for ships, sustainable transportation systems within the port, and electric vehicles instead of traditional fossil fuel-powered vehicles. Additionally, measures are adopted to reduce vessel waiting times at the port, which decreases fuel consumption and carbon emissions (Clavero et al., 2018).
- **Economic Sustainability: Costs and Benefits:** Although transitioning to green ports may require substantial initial investments in infrastructure and modern technologies, the long-term economic benefits can be significant. These benefits include savings on energy costs through the use of renewable energy, reduced waste management costs through recycling, and improved operational efficiency leading to lower operational expenses. Furthermore, green ports may attract more businesses that prioritize sustainability, thereby increasing revenue and enhancing the port's reputation as an environmentally friendly trade hub (Diez-Minguito et al., 2018).

5- Challenges and Obstacles to Transitioning to Green Ports

- **High Costs of Infrastructure Investment:** One of the maximum huge demanding situations in transitioning to inexperienced ports is the excessive charges associated with investing in cutting-edge infrastructure and technologies. The shift to environmentally pleasant practices calls for enormous investments in renewable energy structures, waste management technologies, and upgrading the device and equipment utilized in port operations. These preliminary fees can be a tremendous burden on ports, specifically in growing international locations with restricted economic resources (Bergillos et al., 2018).

- **Technical Challenges and Innovation:** the technologies needed for the transition to green ports are nonetheless in the developmental tiers in some cases, meaning that ports may additionally face technical challenges in adopting those innovations. For instance, implementing clever transportation structures and easy gas technologies calls for superior technologies that might not be effortlessly to be had or can be pricey. Moreover, working those systems requires professional personnel and excessive technical know-how, adding complexity to the transition (Magana et al., 2018).
- **Resistance to Change and Work Culture:** Resistance to trade is one of the limitations facing the transition to inexperienced ports, as port control may face challenges in converting the institutional subculture that is based on vintage and unsustainable practices. Port people might also display resistance to adopting new technology or converting conventional paintings methods, requiring additional efforts in training and elevating cognizance approximately the significance of environmental sustainability (Clavero et al., 2018).
- **Lack of a Supporting Regulatory and Legal Framework:** the absence of a clean regulatory and prison framework supporting the transition to green ports may be a large barrier. In some countries, there may be no criminal guidelines or guidelines encouraging the adoption of environmentally pleasant practices or providing the essential economic incentives for ports to make this transition. This lack of law can result in delays or the vain implementation of inexperienced port tasks (Diez-Minguito et al., 2018).
- **Environmental and Geographical Challenges:** Environmental and geographical conditions can pose obstacles to the implementation of green port technology. For instance, coastal areas liable to herbal disasters which include hurricanes and floods may be wrong for long-term investments in green infrastructure. Additionally, weather change can affect the effectiveness of technology which includes sun and wind power, including an additional layer of complexity to the transition system (Ortega-Sanchez et al., 2018).
- **Funding and Financial Support:** the loss of important funding and monetary help is one in all the most important barriers facing ports attempting to find to transition to green ports. These ports require big financing to cover the costs of latest infrastructure and technology, further to monetary help for training and retraining personnel to deal with modern-day technologies (Paquiero et al., 2018).

6- The Future of Green Ports in Global Sustainability

- In line with the global shift towards sustainability goals, green ports play a crucial role in transitioning to clean energy sources. These ports rely on renewable energy, including solar and wind, to power their infrastructure, thereby reducing dependence on fossil fuels. This shift significantly contributes to reducing greenhouse gas emissions, a critical step in meeting climate change goals outlined in the Paris Agreement. According to López and Guerrero

(2020), green ports serve as models for promoting clean energy use and minimizing the environmental impact of maritime activities.

- Green ports are experiencing significant advancements in waste management, adopting advanced recycling technologies and waste-to-energy conversion systems. These innovations help reduce the amount of waste sent to landfills, conserving natural resources and minimizing environmental impact. Additionally, these technologies contribute to public health improvements by reducing environmental risks associated with marine waste. According to a study published in Maritime Policy & Management, these advancements play a pivotal role in enhancing waste management practices in green ports. (Ortega-Sanchez et al., 2018).
- Green ports aim to enhance their operational performance through the adoption of automation and digitization technologies. Automated systems for unloading and loading ships, inventory management, and vessel movement tracking contribute to reducing port operation time and lowering operational costs. Furthermore, these technologies help mitigate emissions resulting from delays in port operations, improving resource efficiency and minimizing environmental impact. In this context, Jones (2021) highlighted the benefits of automation in optimizing port operations.
- International partnerships and the standardization of environmental practices among ports worldwide are vital for achieving sustainability. By adopting global environmental standards and sharing expertise, green ports can strengthen their role in the international arena and achieve more effective results. These partnerships foster innovation and technology transfer among countries, helping ports adapt to future environmental challenges. A study by Global Environmental Change Journal emphasizes the importance of international collaboration in advancing environmental sustainability and driving innovation in green ports.
- Green ports directly contribute to achieving the United Nations Sustainable Development Goals (SDGs), particularly those related to climate action, clean energy, and marine life conservation. By reducing emissions and enhancing resource efficiency, these ports support these global goals, reinforcing the international community's commitment to transitioning towards a more sustainable economy. According to Port Technology International, green ports are crucial tools for achieving sustainable development on a global scale.
- Green ports are expected to continue evolving in the future, focusing on advancing technological innovations and increasing reliance on artificial intelligence and big data to enhance performance. These advancements will contribute to improving the global competitiveness of ports while achieving a balance between economic growth and environmental protection. Future investments in green infrastructure will be a priority for promoting sustainability. According to Smith (2022), the ongoing development of green ports will be essential in advancing the global sustainability agenda.

7- Research Methodology

This study employs a descriptive-analytical approach, determined as the most appropriate methodology following a review of relevant literature and discussions with field experts. This approach was chosen to systematically gather field data on the phenomenon under study using a comprehensive questionnaire. The questionnaire was carefully developed and distributed to a purposive sample of fifty students, allowing for an in-depth understanding of their characteristics, attitudes, perspectives, and usage behaviors related to the study topic.

Upon retrieval, the questionnaires were subjected to rigorous testing through statistical validation techniques to ensure reliability and validity. The most common responses were identified, and the key criteria agreed upon were subsequently selected. To prioritize these key factors, the Analytic Hierarchy Process (AHP) technique was applied, a decision-making tool effective in multi-dimensional and complex contexts. In this study, AHP facilitated the selection and prioritization of critical elements, based on input from experts and study participants, by assessing the relative importance of each factor.

Through AHP, the research identified the most significant factors impacting the quality of maritime learning, which are essential to emphasize within the current study. This systematic prioritization ensures that the study focuses on the elements that will have the greatest influence on enhancing the quality of maritime education and training.

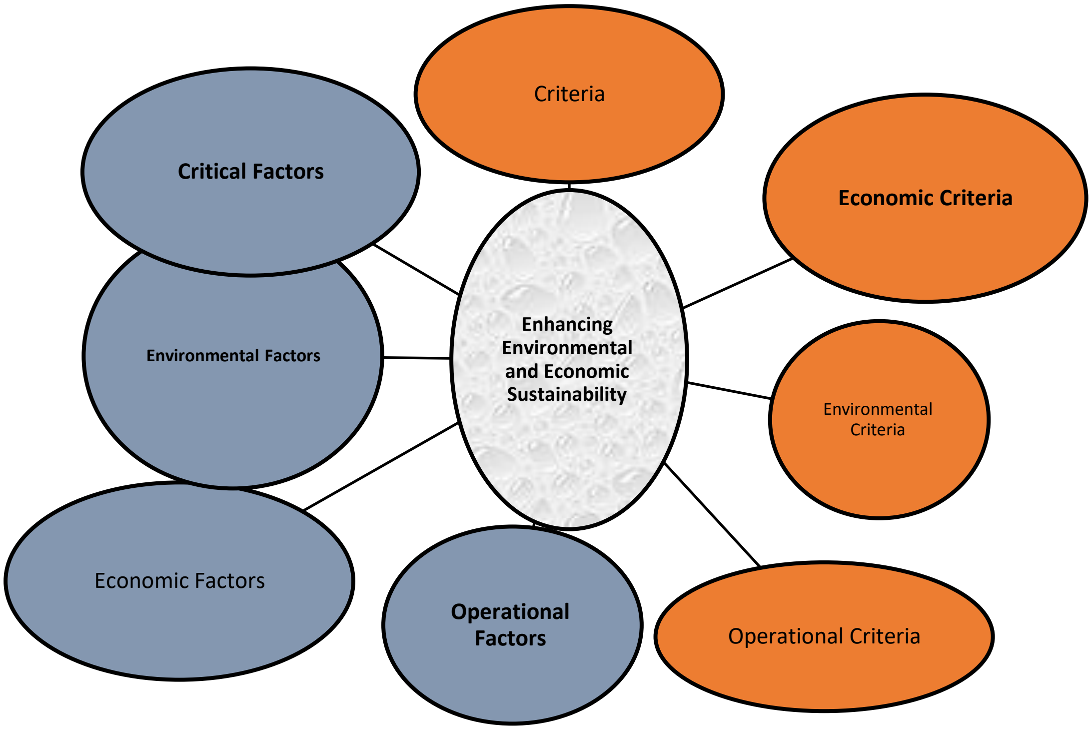

Figure (1): Hierarchical Diagram of the Analytic Hierarchy Process (AHP)

Explanation of the Diagram: -

1. **Main Objective:**

- **Enhancing Environmental and Economic Sustainability**
  The predominant objective is to decorate environmental and economic sustainability via the implementation of inexperienced port standards. This goal is located on the top of the diagram in a square.

2. **Criteria:**

- o Environmental Criteria: Includes key environmental elements consisting of energy performance, waste management, and pollution reduction.
- o Economic Criteria: Includes financial elements consisting of value discount and efficiency development.
- o Operational Criteria: Includes operational factors which include progressed logistics and innovation in sustainable answers.

3. **Critical Factors:**

- o Environmental Factors: Such as power efficiency, waste management, and pollutants reduction, linked to the environmental criteria.
- o Economic Factors: Such as price discount and performance development, related to the economic criteria.
- o Operational Factors: Such as stepped forward logistics and innovation in sustainable answers, connected to the operational criteria.

7-1 AHP Methodology:

The AHP methodology employs a natural, pairwise approach to compare criteria or alternatives in relation to a criterion. The process consists of three main parts:

1. **Identifying Obstacles and Designing a Hierarchy Prioritization Model:** This involves defining the criteria and structuring them into a hierarchical model to prioritize and address obstacles.
2. **Creating a Questionnaire and Gathering Data:** Developing a detailed questionnaire to collect data through pairwise comparisons, allowing for the evaluation of different factors based on expert judgment or stakeholder input.
3. **Determining Normalized Weights:** Calculating the normalized weights for each category of barriers and each individual barrier based on the collected data, which helps in assessing the relative importance of each factor.

8- DATA ANALYSIS

In this section, the software of the AHP method can be clarified to evaluate the effectiveness of implementing inexperienced practices in ports and their impact on achieving environmental and monetary sustainability. AHP changed into adopted as an analytical device to assess the effectiveness of these practices in promoting sustainability through focusing on 3 predominant criteria: (1) Environmental Impact (EI); (2) Technical Infrastructure (TI); and (3) Institutional Readiness (IR).

Table (1) indicates the pairwise comparison matrix furnished through a specialized expert to evaluate the effectiveness of making use of green practices in ports. The highest weight became assigned to Environmental Impact, followed by Technical Infrastructure, and subsequently Institutional Readiness.

Table (1): the pairwise comparison matrix

Challenges	PI	TI	IR	CW	GM	W	WSV
Environmental Impact (EI)	1	1	0.5	1.83	1.83	9.56%	1.83
Technical Infrastructure (TI)	3.45	0.56	1	2.71	2.71	22.9%	2.71
Institutional Readiness (IR)	3.21	0.89	0.5	2.46	2.46	36.8%	2.46
Total	7.66	2	2.45	-	-	7	1

The following values are then calculated to confirm the consistency of the pairwise comparison matrix: -
Since the CR value < 0.1, the matrix is taken into consideration constant and dependable.

Table (2) shows the final decision matrix for evaluating the effectiveness of applying green practices in ports through the three main criteria:
Table (2): the final decision matrix

Criterion	CW	Rank
Environmental Impact (EI)	1.83	3
Technical Infrastructure (TI)	2.71	1
Institutional Readiness (IR)	2.46	2

Table (2) indicates that Technical Infrastructure (TI) ranks first in priority, followed by Institutional Readiness (IR), and then Environmental Impact (EI)

Results of the First Hypothesis Test: There is a significant relationship between the application of green practices in ports and the achievement of environmental and economic sustainability.

Table (3) shows a strong relationship between the application of green practices and the achievement of environmental and economic sustainability, with a correlation coefficient of 0.559 at a significance level of 0.00, indicating a significant statistical correlation.

Table (3): relationship between the application of green practices and the achievement of environmental and economic sustainability

Independent Variable	Dependent Variable	Correlation Coefficient (R)	Coefficient of Determination (R^2)	Significance Level
Application of Green Practices	Achievement of Environmental and Economic Sustainability	0.559	0.313	0.00

Results of the Second Hypothesis Test: There is a correlation between the application of green practices and the increase in operational efficiency in ports.

Table (4) suggests a robust correlation among the software of inexperienced practices and the increase in operational efficiency, with a Pearson correlation coefficient of 0.939 at a significance level of zero.00, confirming the correlation speculation.
Table (4): a robust correlation among the software of inexperienced practices and the increase in operational efficiency

Independent Variable	Dependent Variable	Pearson Correlation Coefficient (R)	Significance Level
Application of Green Practices	Operational Efficiency	0.939	0.00

Results of the Third Hypothesis Test: There is a correlation among the utility of green practices and the boom in pride among people and port provider beneficiaries.

Table (5) shows a strong correlation among the utility of green practices and the growth in pride among employees and beneficiaries, with a Pearson correlation coefficient of zero.918 at an importance degree of zero.00, confirming the validity of the 1/3 speculation.

Table (5): a strong correlation among the utility of green practices and the growth in pride among employees and beneficiaries

Independent Variable	Dependent Variable	Pearson Correlation Coefficient (R)	Significance Level
Application of Green Practices	Satisfaction of Workers and Beneficiaries	0.918	0.00

9- Conclusion and Discussion

In conclusion, the application of sustainable, eco-friendly practices in ports is a crucial step toward achieving both environmental and economic sustainability. These practices aim to enhance ports' environmental performance by reducing negative impacts on the environment and realizing financial benefits, such as cost reduction and improved operational efficiency.

Additionally, implementing green practices boosts the reputation of ports and increases the satisfaction of employees and stakeholders, positively impacting overall port performance and contributing to long-term sustainability. To maintain this progress, it is essential for ports to continuously monitor the implementation of these practices and regularly assess their effectiveness, ensuring ongoing improvement and the achievement of targeted sustainability goals.

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Bridging Maritime Communication Gaps: The Role of LEO Satellites in Expanding Global Connectivity

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المستخلص:
يُعد الاتصال المباشر بين أجهزة المحمول والأقمار الصناعية أحد أهم التحديات التي تواجه قطاع الاتصالات في السنوات القادمة، حيث ظلت الاتصالات عبر الأقمار الصناعية مقتصرة على استخدامات معينة، منها تحقيق الاتصال بين السفن والمحطات الساتلية الأرضية خلال الرحلات الدولية. غير أن السنوات الماضية شهدت طرح فكرة استخدام الأقمار الصناعية لتوفير التغطية في المناطق التي تعاني من ضعف التغطية من قبل شركات المحمول.

في هذا السياق، بدأت بعض الشركات، مثل شبكة "ستارلينك" التابعة لـ"سبيس إكس"، في إطلاق أعداد كبيرة من الأقمار الصناعية التي تعمل في المدارات الأرضية المنخفضة(LEO) ، والتي تهدف إلى تحقيق اتصال مباشر مع أجهزة الهاتف المحمول.

تتناول هذه الورقة البحثية الفرص والتحديات التي تواجه مجموعات الأقمار الصناعية الضخمة وشبكات الأقمار الصناعية في مجال النقل البحري. كما تناقش سبل الاستفادة من القمر الصناعي "طيبة-١" لتوفير اتصال موثوق للسفن داخل المياه الإقليمية المصرية وفي المناطق النائية التي يصعب تحقيق اتصال بينها وبين المحطات الأرضية.

ABSTRACT
Direct device -to-device is the latest and potentially the biggest opportunity in the telecom business as the gap between satellite and ground communication is narrowing. Respectively, the telecom companies and mobile network operators are interested in increasing the coverage of their telecom networks which will boost the quality of services and will increase the revenues as well. In this regard, Low-earth-orbit (LEO) satellite mega-constellations, such as SpaceX Starlink, are under fast deployments and promise broadband Internet to remote areas that terrestrial networks cannot reach. This paper will investigate the opportunities and challenges facing the LEO mega-constellation and satellite networks in the maritime industry.

Keywords: LEO Satellites, Maritime Communication, Satellite Mega-Constellations, Global Navigation Satellite Systems (GNSS), Starlink, SpaceX, Broadband Internet, Global Connectivity, Maritime Navigation, Tiba-1 Satellite

1- INTRODUCTION

Since the very beginning of the implementation of the GNSS technology, GNSSs have shown significant expansion in terms of both adoption and technological advancement. The Global Positioning System (GPS) was created by the US government in the early 1970s and made fully operational in 1995, was the first GNSS. Nearly concurrently constructed and completely operational by 1995 was the Russian system GLONASS. Consequently, some other satellite constellations such as BeiDou and the Galileo system have been providing navigation and communication via GNSS technology for regional and global navigation. Moreover, regional standalone or augmentation systems have been created by Japan and India (NavIC and QZSS, respectively) (Egea-Roca, et al., 2022).

The United States GPS launched for general usage in 2000 after being deemed fully operational in 1995 with 24 satellites offering worldwide coverage. Accuracy was about 10 meters at the time, over 125 navigation satellites were in operation by the year 2020, with three more global satellite navigation systems having been implemented by other countries since then.

The majority of GNSS systems operate with as few as five satellites, however many satellite constellations rely on more than 25 satellites in providing the navigation services to their users. Respectively, it is crucial to have this redundancy for several reasons. Since a huge portion of the sky can now be blocked by local barriers without affecting GNSS performance, the abundance of satellites boosts GNSS availability (Weiqiang, et al., 2021).

The MEO satellites are situated between 8,000 and 20,000 kilometers above the surface of the Earth. This particular positioning has a critical impact on GNSS/GPS antenna operation. Satellites operating at this height are able to cover a larger region with a lower latency than their counterparts in Low Earth Orbit (LEO) and Geostationary Orbit (GEO). For a broad range of GNSS applications, including precision farming and marine navigation, this makes MEO satellites essential.

All ships, regardless of size, must have a receiver for a GNSS or a terrestrial radio navigation system in accordance with SOLAS Regulation V/19.2.1.6. To ensure adherence to the SOLAS guidelines, these days, GNSS receivers are incredibly dependable and user-friendly. A variety of applications on ships and are a significant source of both in terms of time and placement. Activities that take place in maritime surroundings (IMO, 2023).

In this regard, The IMO resolution A.1046 (27) on the global radio navigation system includes the main technical requirements for all radio navigation systems on board of IMO vessels. Respectively, the satellite positioning systems already recognized by IMO as meeting the required standards in order to be used as a component of the WWRNS include GPS (since 1995), GLONASS (since 1996) and Beidou (since 2014).

Consequently, The Automatic Identification System is an advanced system that allows vessels on the sea and rivers to be identified by their routes. It does this by transmitting important data regarding the identity of the ship, its cargo, key characteristics, and its navigation status at all times of day or night. When paired with an inland ECDIS, the AIS system—which was initially implemented in river and maritime navigation—allows for the practical replacement of a large portion of the position and distance data for nearby vessels, greatly increasing navigation safety.

In this Respect, according to the IMO regulation, all passenger ships, regardless of size, cargo ships, with a gross tonnage of 500 or more that are not involved in international trips, and ships with a gross tonnage of 300 or more that are engaged in international voyages must have AIS installed.

The use of satellites to track fishing activity has been implemented in many countries across the globe. In this regard, The European Union (EU) has deployed a satellite-based vessel monitoring system (VMS) which entails to track the fishing vessels activities on a regular basis (Maina, et al., (2018). Alternatively, In the United States 4,000 vessels are monitored by the VMS, which represents the world's largest national VMS fleet. The VMS data is shared with designated authorities which includes the U.S. Coast Guard, academics, and the coastal states (Fisheries, 2024).

A satellite in low-Earth orbit (LEO) typically orbits hundreds of kilometers above the planet in a much lower orbit. Approximately 100 kilometers above the International Space Station, the original Starlink constellation orbits at a distance of about 550 km.

According to Business Research Insights, the LEO satellite market is anticipated to expand from over US $4 billion in 2022 to about $7 billion in 2031 (*Broadband Connectivity*, 2023). The most famous LEO broadband communications satellites are likely SpaceX's Starlink spacecraft, however, Amazon has started launching its own Project Kuiper spacecraft and plans to start operations in 2024. Not only are other businesses joining the market to supply broadband connection, but they are also producing the smaller rockets. Airbus, Ariane Group, China Aerospace Science and Technology Corp., and Tata Advanced Systems are a few of them (Androjna, et al., 2020).

Starlink Internet broadband is a highly advanced system that uses space to carry information quicker than fiber optic cables, allowing for faster access to more people and places. Starlink is a constellation of many satellites in low Earth orbit (LEO), unlike conventional satellite Internet systems that rely on single geostationary satellites orbiting around 35,000 km. Starlink satellites are in low orbit, resulting in significantly lower round-trip data time (delay) compared to geostationary satellites.

The Starlink satellite project aims to provide high-speed internet connection to rural places in developing countries, potentially boosting economic development and social welfare. Concerns have been expressed regarding the potential detrimental impact on local Internet service providers and the possibility of establishing a digital divide between those who can afford and those who cannot.

Establishing a rural network presents further challenges due to increased capital and operating costs in addition to the lower average revenue per unit ARPUs ,the Security challenges , distant location, and inconsistent power are among the challenges facing the telecom operators to expand their coverage to the rural areas .In the past few years , some of the obstacles have been partially overcome by using off-grid electricity and establishing microwave towers every 20 to 30 kilometers (instead of fiber optics). However, there is still a security breach, and theft is still a serious risk, particularly in underdeveloped nations.

On the satellite Internet providers that provide worldwide connectivity have become more prevalent in the US market. Organizations such as O3B, SpaceX, and One Web aim to create satellite constellations that provide a global internet connection.

According to (Mukto, M. M., et al, 2022) 45% of the internet users will prefer to use satellite internet services over the internet service provided using Ethernet cables due to the environmental impact of the copper discharge in the environment.

According to ITU Global Connectivity Report 2022, 67 percent of the global population, or 5.4 billion people, is currently online. This highlights global internet adoption, with billions of people benefiting from digital access. However, the ITU report demonstrated that the digital gap remains a key concern. In low-income nations, where internet connectivity has grown the most rapidly, less than one-third of the population has access to the internet. Despite a 17 percent growth in internet users in these regions over the last year, the majority of individuals in these countries remain isolated from the internet (Weiqiang, et al., 2021).

Broadband service providers who primarily rely on terrestrial networks have found it unprofitable to provide broadband connectivity in these rural areas via the fiber network infrastructure. In this regard, satellite service providers are offering broadband connectivity with high speeds and competitive prices in comparison to terrestrial service providers. Satellite communications services can contribute to the decrease of the existing connection gap between the developed and undeveloped countries or between the urban and rural areas within the same country (Graydon, & Parks, (2020).

On the other hand, Among the 17 Sustainable Development Goals (SDGs) is the SDG 9 which aims to increase the investments in ICT access and quality education to promote lasting peace, which aims to increase the number of people connecting to the internet, reducing the digital divide between the developing and developed countries or between the urban and rural areas within the same country (Martin, 2023).

2- LITERATURE REVIEW

According to (Androjna, et al, 2020) one of the main challenges facing the implementation of the GNSS technologies in the maritime domain is the automatic update of the location every 15 minutes regardless of the type of vessel and the type of operation or maneuvering involved in. From another perspective, the implementation of new technologies promoted by the IMO as the new trends in maritime transportation such as e-navigation, e-maritime services, and MASS, all require an efficient utilization of the GNSS.

Weiqiang, et al. (2021) investigated the potential challenges facing the implementation of the GNSS technology in the navigation systems of the autonomous vehicle.

Ilcev, (2022) explores alternative satellite systems that could enhance the GMDSS network, including Low Earth Orbit (LEO) and Medium Earth Orbit (MEO) satellites. These alternatives promise better global coverage, lower latency, and potentially reduced costs.

Innac, et al, (2022) evaluated the European Geostationary Navigation Overlay Service EGNOS utilization in the maritime navigation, the research examined the satellite visibility during in different navigation situations, in this respect, the number of GPS satellites during navigation varied from a minimum of six satellites to a maximum of ten, with an average of eight visible GPS satellites also guaranteeing a solution availability and continuity equal to 100%.

Li, Wang, Xu, & Xu, (2024) examined how cloud and edge computing operate together in satellite networks by using game theory. The interactions between various network nodes, including as satellites, edge devices, and cloud servers, are modeled using game theory with the goal of establishing a compromise between maximizing detection accuracy and decreasing resource usage.

Pekkanen, Aoki, & Mittleman, (2022). Highlights the significance of big data in handling and interpreting the enormous volumes of data that tiny satellites are collecting. Finding patterns, anomalies, and trends that can point to questionable or unlawful activity in maritime environments is made possible by big data analytics.

Oligeri, et al., (2020) examined an adversary model that detects spoofing on the IRIDIUM signals through the utilization of a GNSS spoofing software tool, an antenna, and an SDR.

Respectively, Androjna, & Perkovič, (2021) investigated the strengths and weaknesses of the AIS system using SWOT analysis, one of the threats was the vulnerability of the AIS service threatening attack as spoofing of ships that may mislead national authorities regarding maritime surveillance, while among the opportunities of the AIS application was its contribution in reduce the rate of collisions among the navigating vessels.

Alternatively, The US Radio Technical Commission for Maritime Services (RTCM) examined in conference document NCSR 11/6/5 the viability of combining class D DSC and class B AIS radios to a single VHF antenna, during its examination, RTCM took into account the effect that a transmitting VHF radiotelephone has on the AIS receiver. This included the case of combination units that use two VHF antennae instead of one, as well as the case of separate AIS and VHF radios installed on different vessels.

Maina, et al (2018) utilized the Vessel Monitoring System VMS data over a 6-year period (2010–2015) to investigate the spatiotemporal patterns of fishing effort of Greek trawlers operating in the Aegean Sea.

Fournier, et al., (2018) explored the S-AIS applications from 2004 to 2016: The article reviewed the different ways that S-AIS technology was used during this time, such as:

Monitoring vessel movements to avert collisions and mishaps is known as maritime safety.

Security: keeping an eye on ship movements to spot and stop illicit activity like smuggling and piracy.

Monitoring the environment: Assisting in the tracking and remediation of environmental risks such as oil spills.

Search and rescue: Helping to find and organize rescue efforts for vessels that are in trouble.

Fisheries Management: observing fishing operations to make sure rules are being followed.

Alternatively, et al., (2023) highlights the main obstacles to maritime broadband communications, including the threatening maritime environment, latency, and coverage gaps. It addresses possible solutions, such as mesh networks, adaptive communication methods, and the placement of Low Earth Orbit (LEO) satellites.

3- SWOT Analysis of GNSS Technologies and Satellite Systems in the Maritime Sector

A SWOT analysis is an approach in strategic planning that helps determine and assess project's, companies, or initiative's Strengths, Weaknesses, Opportunities, and Threats. Internal factors like assets, abilities, or procedures that either facilitate success or provide difficulties are referred to as strengths and weaknesses. External elements that may have an impact on an organization's success are known as opportunities and threats. These factors could include competition, market trends, or economic situations. A SWOT analysis evaluates these four areas to assist entities in creating plans to take advantage of opportunities, address weaknesses, exploit strengths, and minimize threats, respectively, in this respect, we are going to demonstrate a SWOT analysis of GNSS and satellite systems the maritime sector the data review in the literature.

INTERNAL FACTORS

STRENGTHS +	WEAKNESSES –
• **Global Coverage and High Accuracy:** • GNSS and satellite systems provide comprehensive global coverage, ensuring vessels can navigate accurately across vast and remote oceanic areas. • EGNOS and other GNSS enhancements improve GPS reliability, ensuring continuous and precise positioning data. • **Enhanced Safety and Security:** • Satellite systems like S-AIS contribute to maritime safety by enabling vessel tracking, reducing collision risks, and facilitating search and rescue operations. • The integration of LEO and MEO satellites in GMDSS can enhance global maritime distress and safety communications. • **Support for Advanced Maritime Operations:** • GNSS technologies are vital for emerging trends such as e-navigation, MASS, and e-maritime services, providing the necessary infrastructure for efficient and safe operations. • Big data analytics in satellite systems help in monitoring and interpreting maritime activities, enhancing security and environmental protection.	• **Vulnerability to Interference and Spoofing:** • GNSS signals can be vulnerable to spoofing and jamming, which can lead to misleading navigation data and pose security risks. • AIS systems, despite their benefits, can be susceptible to cyber-attacks, potentially compromising maritime surveillance. • **Technical Challenges and Limitations:** • Automatic updates every 15 minutes regardless of vessel type or operation can lead to inefficiencies, particularly in dynamic maritime environments. • Latency issues in maritime broadband communications, especially in challenging environments, can hinder real-time data transmission and coordination. • **Dependency on Infrastructure:** • The effectiveness of GNSS and satellite systems is heavily dependent on the infrastructure's reliability, including ground stations and satellite networks. Any disruption can impact maritime operations significantly.

Figure 1 – demonstrates the strengths and weaknesses of the deployment of GNSS and satellite systems the maritime sector.

EXTERNAL FACTORS

OPPORTUNITIES +	THREATS –
• **Technological Advancements:** • The development of new satellite technologies, such as LEO and MEO constellations, offers opportunities for improved coverage, lower latency, and reduced costs in maritime communications. • Integration of cloud and edge computing with satellite networks can enhance data processing capabilities, allowing for more efficient and accurate maritime operations. • **Expansion of Services:** • Tiba-1 and similar satellites can extend broadband connectivity to remote maritime regions, reducing the digital divide and supporting economic growth in coastal communities. • The adoption of e-navigation and MASS creates opportunities for the maritime sector to optimize operations, reduce costs, and improve safety through automation and better data utilization. • **Environmental Monitoring and Compliance:** • Satellite systems enable better environmental monitoring, such as tracking sea conditions and pollution levels, helping the maritime industry meet regulatory requirements and protect marine environments. • VMS data and S-AIS applications can aid in sustainable fisheries management by ensuring compliance with fishing regulations and preventing illegal activities.	• **Regulatory and Legal Challenges:** • The adoption of new GNSS technologies and satellite systems may face regulatory hurdles, particularly regarding international standards and the integration of new systems with existing maritime infrastructure. • Legal issues related to the cybersecurity of GNSS and AIS systems could pose challenges, especially concerning liability in the event of system failures or breaches. • **Environmental and Operational Risks:** • Harsh maritime environments can impact the performance and reliability of satellite communications, posing risks to navigation and safety. • The maritime industry may face operational disruptions due to space weather events, such as solar storms, which can affect GNSS signals and satellite communications. • **Competition and Market Dynamics:** • The rapid development of new satellite systems and technologies may lead to increased competition, which could affect the pricing and availability of satellite-based services. • Emerging alternatives to traditional GNSS, such as terrestrial-based positioning systems, could potentially reduce the reliance on satellites, impacting the satellite services market.

Figure 2 – demonstrates the opportunities and threats of the deployment of GNSS and satellite systems the maritime sector.

4- CASE STUDY TIBA-1 AND NILE SAT 301

The Egyptian satellite Co. Nilesat was established in 1996, for the purpose of operating DTH broadcasting satellites and up-linking facilities. Nilesat is broadcasting digital TV channels and digital radio channels, in addition to data transmission and turbo internet services.

Nilesat offers various communication services in the Middle East and North Africa (MENA) region, including satellite broadband over Egypt and direct-to-home (DTH) broadcasting. Millions of homes, companies, and governmental institutions get a vast array of television and radio stations, as well as data and internet connectivity, from its fleet of geostationary satellites.

Currently operating Nilesat 201, Nilesat 301, and previously Nilesat 101, Nilesat 102, and other satellites in the 7° West orbital slot are all part of Nilesat's fleet, over 100 million households are covered by these satellites throughout a large territory that includes portions of Africa and the MENA regions.

On November 26, 2019, the Egyptian telecom satellite Tiba-1 was launched. The 300-hour voyage culminated in the satellite's launch into orbit. In September 2021, the satellite's extensive testing was finished.

The satellite's goal is to give the public and private sectors access to space communications. The 5600 kg satellite, orbiting at 35.5° E, is traveling at 11,000 km/h while 36,000 km above Earth. Egypt and the economic waterways are covered by the satellite. It also spreads to a few adjacent nations and the nations of the Nile Basin.

Tiba 1 offers satellite communications services both inside and outside the nation's borders, encompassing one-third of the planet.

Covering one third of the globe, Tiba 1 provides satellite communications services inside and outside the Egyptian borders.

The Tiba 1 satellite was created in Egypt without the assistance of any foreign experts, and it is equipped with high-quality, high-resolution cameras for the satellite imaging service. It was produced by the French firms "Airbus" and "Thales Alenia Space," with Egyptian professionals involved in every phase of the production process, from design to operation

Tiba 1 provides complete coverage to some nations in the Nile Basin and North Africa, as well as communications services to the commercial and governmental sectors.
Tiba1 satellite contributes to development by bridging the digital divide between urban and rural areas and supporting development projects in remote and isolated locations by delivering internet and broadband communications infrastructure.

Based on the transponder bandwidth, frequency band (such as C-band, Ku-band, or Ka-band), and the particular service being offered, TIBA-1 are made to accommodate a range of data speeds. For instance, whereas C-band and Ku-band satellites may support lesser data rates, Ka-band satellites frequently enable higher rates, occasionally approaching gigabits per second (Gbps).

In this respect Tiba 1 has the capacity to provide one of the following Services; (The Egyptian Satellite Company, 2024)

- Service packages for internet access for home subscribers (The Egyptian Satellite Company
- VOIP
- Land mobile
- Maritime
- Aeronautical
- Backhauling
- Trunking
- Oil & Gas
- enterprices
- ministries and government agencies Services
- content distribution
- Platforms (VIP – Shahid)
- Internet of things IOT

5- COMPARISON BETWEEN THE CAPABILITIES OF STUDY TIBA-1 AND NILE SAT 301

	Tiba-1	**Nilesat**
Purpose	Telecommunication, Data Communication	direct-to-home (DTH) broadcasting satellite system
Frequency Bands	Ka-band	Utilizes Ku-band for broadcasting and Ka-band for data services.
Coverage	Focused on Egypt, with additional coverage extending over North Africa and the Middle East.	Covers the Middle East, North Africa, and parts of Sub-Saharan Africa, focusing on broadcasting services.
Data Handling Capacity	Tiba-1 is equipped with advanced communication payloads that can handle high-capacity data transmission	While Nilesat does offer broadband services, its primary focus on broadcasting means its capacity for data transmission is more limited compared to satellites like Tiba-1,

6- TIBA-1 UTILIZATION IN THE MARITIME SECTOR:

The capabilities of Tiba-1 can be applied to a range of maritime applications, with a focus on improving connectivity and communication for vessels that are within its coverage area. The maritime sector can make use of Tiba-1 in the following ways:

6-1 Improved Vessel Communication

Broadband Internet Access: Ships operating at sea, particularly those in areas unreachable by conventional terrestrial networks, can benefit from Tiba-1's high-speed internet connectivity. For data transfer, online service access, and real-time communication.

By supporting VoIP and satellite communication, the satellite makes it possible for maritime crews to stay in touch even when they are in far-off places.

6-2 Navigation and Safety:

Tiba-1 can help GNSS-based applications by providing a stable communication channel for the transfer of GNSS correction data, improving the accuracy and dependability of positioning data for marine navigation even though it is not a GNSS satellite.

Data from the Automatic Identification System (AIS), which is necessary for tracking vessel movements and enhancing marine safety, can be transferred more easily with the help of Tiba-1.

Through Tiba-1, ships may transmit and receive AIS data, making themselves visible to other ships and maritime authorities.

6-3 Maritime Monitoring and Surveillance:

The Vessel Monitoring System (VMS), which keeps tracks on the location and activities of other ships and fishing vessels, is compatible with Tiba-1. In order to maintain maritime security, avoid illicit fishing, and comply with regulations, this is very crucial.

Enabling the transfer of data from sensors and devices on board ships, the satellite can help with environmental monitoring. This data may contain details about the state of the sea, the weather, and pollution levels in the environment.

6-4 Emergency Response and Disaster Management:

Tiba-1 can offer an essential means of communication for distress signals, rescue operation coordination, and real-time updates to and from ships in the case of an emergency at sea, such as a natural disaster.

6-5 Supporting Maritime Economic Activities:

Commercial Operations: Tiba-1's high-speed connectivity can improve commercial shipping operations such as fleet coordination, logistics management, and cargo tracking.

Fishery sector: By guaranteeing regulatory compliance, boosting vessel safety, and optimizing fishing operations' efficiency, Tiba-1's services can help the fishing industry**.**

6-6 Reducing the Digital Divide in Maritime Communities:

Connectivity for Coastal Communities: Tiba-1 is able to provide internet and communication services to ports and coastal communities, which are essential for integrating with international trade networks and fostering economic growth.

7- CONCLUSION

By bridging the gaps in global connection, the combination of LEO satellites and other satellite technologies like Tiba-1 is transforming maritime communication. LEO mega-constellations like Starlink and regional satellites like Tiba-1 are emerging as crucial options, providing dependable and fast internet connection to vessels and coastal towns, as traditional terrestrial networks struggle to reach remote places. These developments are critical to guaranteeing safety through systems like AIS and VMS, as well as improving real-time communication and navigation for maritime operations.

Furthermore, by offering necessary broadband services, these satellite technologies are significantly contributing to closing the digital divide, especially in rural and developing nations. This connectedness facilitates improved emergency response and catastrophe recovery, enhances safety and monitoring, and promotes economic development.

By utilizing LEO satellite constellations as Tiba-1 that promote connectivity to the rural and urban areas, which represent an opportunity for maritime communication in the local and regional sea areas. Through the deployment of this satellite constellation, the maritime sector is set to experience greater efficiency, safety, and economic growth as the industry continues to progress.

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Legal Challenges Within the Framework of International Maritime Conventions Pertaining to Autonomous Ships

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المُستخلص:
يقدم البحث تحليلًا مفصلًا لمفهوم السفينة المُسيرة ذاتياً (MASS) ويقيّم التحديات المتعلقة بإطار الاتفاقيات البحرية الدولية. يتناول الإجراءات التشغيلية الأساسية التي تحكم تشغيل هذه السفن، مع استعراض أهم اللوائح الحالية، مما يساهم في توفير فهم واضح للإطار التنظيمي الراهن.
تم استخدام منهج بحث وصفي تحليلي لتحليل وتفسير النصوص القانونية. شملت الدراسة مراجعة دقيقة للإجراءات التشغيلية الرئيسية واللوائح الحالية، حيث تم دمج البيانات التي تم جمعها وتحليلها للإشارة إلى عدد من الحلول والنهج المحتملة للتغلب على التحديات ضمن إطار الاتفاقيات البحرية الدولية.
أبرز البحث مجموعة من الحلول المبتكرة والاستراتيجيات التي يمكن تبنيها لمواجهة التحديات المحددة. كما شدد على أهمية تطوير نهج متعدد الأبعاد يدمج بين الجوانب التقنية والقانونية والتنظيمية لضمان سلامة وكفاءة تشغيل السفن المُسيرة ذاتياً.

الكلمات الافتتاحية: مَفهوم السفينة، السُفن السطحية المُسَيرة ذاتياً MASS، الصكوك القانونية، الإتفاقيات البحرية الدولية.

ABSTRACT
A comprehensive analysis of the Maritime Autonomous Surface Ships (MASS) concept is presented, along with a detailed evaluation of the challenges related to the framework of international maritime conventions. The essential operational procedures that govern the functioning of these ships are thoroughly examined, and a review of the most significant current regulations is conducted, thereby contributing to a clearer understanding of the existing regulatory framework.
A descriptive and analytical research methodology has been employed to analyze and interpret legal texts. Following a thorough review of the primary operational procedures and current regulations, the collected data were analyzed and synthesized, identifying several potential solutions and approaches to overcome the challenges within the framework of international maritime conventions.
Through this review, various innovative solutions and strategies that can be adopted to address the identified challenges are highlighted. The importance of developing a multidimensional approach

that integrates technical, legal, and regulatory aspects to ensure the safety and efficiency of these ships is emphasized.

Keywords: MASS, Autonomous Ships, Legal Frameworks, International Maritime Conventions.

1. Introduction

Autonomous vehicles, such as drones, self-driving cars, and now autonomous ships, have become essential to everyday existence. This technological progress poses fresh challenges and creates prospects for developing international maritime law to align with these transformations. The lack of a dedicated legal framework for autonomous ships results from existing maritime laws formulated using principles derived from international conventions and treaties established more than two centuries ago. Field trials on large autonomous vessels designed for long voyages underscore the necessity to develop and amend regulatory legal frameworks to accommodate these new technological innovations (Pundars, 2020).

The primary obstacle in determining whether autonomous ships are subject to existing international maritime law lies in addressing the diverse range of capabilities that autonomy encompasses. Unmanned or autonomous ships should not be considered a uniform group but a category encompassing various types. Given the swift progress in artificial intelligence and automated control, it is crucial to reevaluate and implement current maritime laws and regulatory frameworks. These laws are derived from the fundamental premise that a captain and crew are present on the ship. Hence, there is a necessity to redefine the conventional responsibilities of the crew and the involvement of artificial intelligence and remote control crews in autonomous maritime transportation (Issa et al., 2022). In 2017, the International Maritime Organisation (IMO) took a significant step by initiating the scoping of relevant legislation, which was crucial for progress in this area. This procedure necessitated an examination of legal documents to guarantee the secure planning, building, and functioning of self-governing vessels and verify that the legal structure offers operational safeguards on par with those accessible for traditional ships (IMO, 2018)

In 2021, the Maritime Safety Committee (MSC) continued the process of regulatory scoping. The objective was to evaluate how IMO instruments could be applied to ships with different levels of automation. The committee agreed on a framework for the regulatory scoping process concerning utilizing MASS. The following degrees of automation for this process were defined in Figure (1) (Mohamed & Elnoury, 2023):

- **Degree One**: Vessels equipped with automated processes and decision support systems, with seafarers on board to manage and oversee shipboard systems and functions. Certain operations can be automated and sometimes unsupervised; seafarers are prepared to assume command while on board.

- **Degree Two**: Ships operated by remote control but still have seafarers on board. The vessel is remotely operated and controlled from a separate location, while seafarers are present on board to oversee and manage the ship's systems and operations.
- **Degree Three**: Unmanned ships controlled from a distance, with no crew members on board. The vessel is remotely operated and controlled.
- **Degree Four**: Fully autonomous ships equipped with an operating system capable of independently making decisions and executing actions.

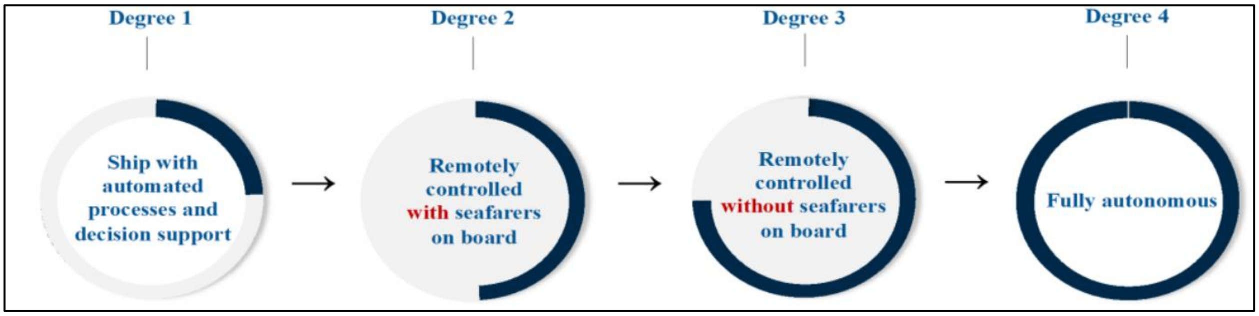

Figure 1. Degrees of autonomy as defined by IMO (2018)

The methodology for this regulatory scoping process consists of two steps. First, for each safety and security-related instrument and each degree of automation, provisions are identified that apply to different scenarios: provisions applicable to MASS and prohibiting its operation; those relevant to MASS without preventing its operation but requiring no measures; provisions applicable to MASS but possibly needing amendments or clarifications and having gaps; or those not relevant to MASS operations (IMO, 2018). Second, the most appropriate approach to address MASS operations is analyzed, considering human elements, technology, and operations factors. The analysis will determine whether it is necessary to provide equivalents as per the instruments, prepare interpretations, amend existing instruments, develop new instruments, or decide that none of these actions are required based on the research results.

This research paper aims to identify and examine the legal challenges within the framework of international maritime conventions related to MASS. A descriptive and analytical research methodology is employed to analyze and interpret legal texts. After reviewing the main operational procedures and current regulations, the collected and analyzed data were synthesized to propose several potential solutions and approaches to overcome the challenges identified within the international maritime conventions included in this process. As in Figure (2), These conventions are as follows:

Figure 2. Identification of international maritime conventions

- The International Regulations for Preventing Collisions at Sea (**COLREG**), 1972.
- The International Convention for the Safety of Life at Sea (**SOLAS**), 1974, as amended.
- International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (**STCW**), 1978, as amended.
- The International Convention for Preventing Pollution from Ships (**MARPOL**), 1973.

2- The relationship between MASS and SSCC

The given Figure (3) depicts the complex correlation between MASS and the Ship-Shore Control Centre (SSCC), highlighting their interdependent functions in autonomous maritime operations. The MASS is equipped with an advanced decision-making system that incorporates a range of sensors, including RADAR, AIS, LIDAR, cameras, and sonar. These sensors collect extensive data about the ship's surroundings. In addition, the ship utilizes automated reporting mechanisms and sophisticated navigation systems such as GNSS and INS to guarantee precise position, course-plotting and instantaneous data transmission to the SSCC. The ship's onboard operating system improves situational awareness and self-diagnosis capabilities, allowing it to independently manage machinery and equipment using intelligent control systems, which include robotic maintenance and repair. Energy optimization and monitoring systems are incorporated to ensure optimal energy utilization.

Additionally, the SSCC is crucial in ensuring the safety and efficiency of MASS. The SSCC's safety system includes smart alarms and controls to prevent accidents like collisions and groundings. It provides safety support and maintains continuous awareness of the ship's operations. The remote control system allows the SSCC to monitor and manage the ship's navigation, sensors, machinery, and equipment, ensuring real-time supervision and intervention when necessary. The constant data exchange between the MASS and the SSCC ensures that the autonomous vessel operates safely and efficiently. This highlights the essential collaboration required for successful autonomous maritime operations (Mallam et al., 2020).

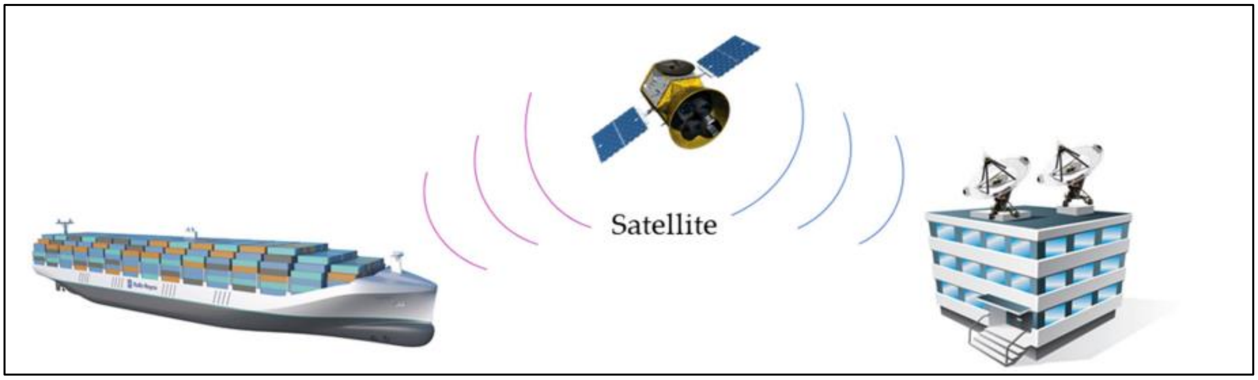

Figure 3. The relationship between MASS and the ship-shore-control-center (SSCC)

3. Ship's definition within the Framework of IMO Conventions

Firstly, it is important to acknowledge that the idea of a ship is essential to numerous international conventions. Nevertheless, no globally accepted international definition of "ship" exists. Typically, international agreements establish the meaning of the term "ship" in particular articles to specify the extent to which they apply. The definitions may differ depending on the characteristics of the convention, whether it relates to general or specific maritime law. The extent of these definitions is contingent upon the specific objective of the international convention. As a result, the range of situations where the convention can be applied will vary depending on the specific convention (Komianos, 2018).

The importance of defining the term "ship" and whether "autonomous or self-driving ships" qualify as ships in the conventional sense lies in the fact that traditional ships enjoy many rights and freedoms stipulated in international conventions, such as the right of innocent passage at sea (Lim, 2018).

It is noteworthy that no definition of the term "ship" is found in the United Nations Convention on the Law of the Sea (UNCLOS) of 1982, despite it being the most significant maritime convention concerning the term "vessel or ship." Although there are numerous references throughout its articles, the text of UNCLOS uses both terms interchangeably, with no distinction in English. The term "ship" is used exclusively in the official Arabic convention translation. The absence of a definition in the convention is crucial because the topics it governs—such as the nationality of the ship, its legal status, or the flag it flies—are primarily based on the provisions of UNCLOS. The lack of a definition in the convention implies that its provisions will apply to both traditional ships and MASS. Thus, autonomous ships (MASS) will benefit from the rights outlined in this convention, such as freedom of navigation on the high seas and innocent passage rights in territorial waters (IMO, 2019).

The same applies to many international maritime conventions concerning specific maritime laws that focus on ships, as they do not provide any definition of a ship. Examples include the 1910 Brussels Convention for the Unification of Certain Rules of Law concerning Collisions between Vessels, the 1976 Convention on Limitation of Liability for Maritime Claims, and the 1926/1993 International Conventions on Maritime Liens and Mortgages. It is worth mentioning that the lack of definitions does not affect or change the current status of existing maritime conventions or treaties when using autonomous ships, provided these ships meet the technical requirements specified for definitional purposes (Lützhöft et al., 2019).

4. Method

The research provides a comprehensive description of MASS, as illustrated in Figure (4). The researcher adopted a descriptive and analytical research methodology to identify and examine the legal challenges related to the development and deployment of such ships. This involved a thorough review of existing operational procedures and an in-depth interpretation of legal texts within the frameworks of international maritime conventions. The collected data was then integrated and analyzed to highlight key challenges and gaps in current maritime regulations.

Based on this analysis, various innovative solutions and strategic approaches were developed to address the identified challenges. These solutions consider the technical, legal, and regulatory aspects necessary to ensure the safety and efficiency of autonomous maritime operations. The research aims to provide actionable insights that will improve maritime safety, security, operational use, and productivity, thereby facilitating the future deployment of MASS.

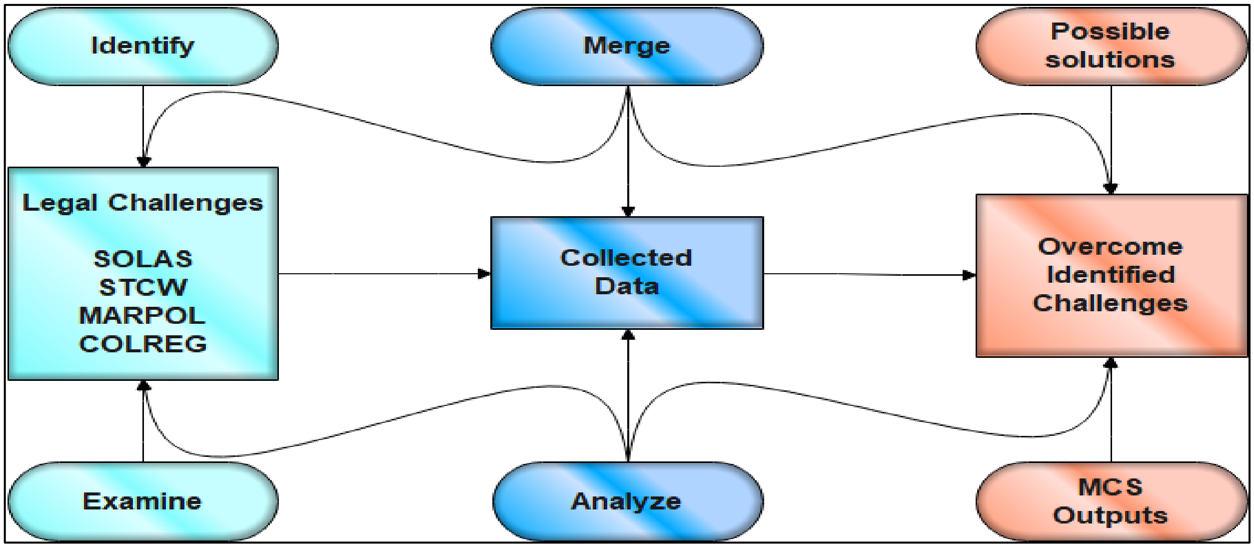

Figure 4. Framework for analyzing and overcoming legal challenges in MASS

5- Issues and Challenges Facing the Regulatory Process

A reassessment of the technical and legal regulations of maritime safety, environmental preservation, and training and monitoring standards is necessary in light of the assumption that humans would carry out specific tasks in the context of MASS. A few examples are enough to demonstrate the deficiencies of the current regulatory framework when applied to the operations of MASS without any changes (Zhang et al., 2022).

5-1 COLREG, 1972

The International Regulations for Preventing Collisions at Sea, 1972 (COLREG), is an international treaty established to prevent ship collisions at sea. Adopted by the International Maritime Organization (IMO) in 1972 and effective from 1977, it includes rules for ship behavior, maneuvering, lights, and sound signals under various conditions. These regulations are binding on all ships in international waters and those flying the flag of a state party to the convention. COLREG is integral to national maritime legislation and fundamental to marine training and certification for seafarers (IMO, 1972).

Under the first degree of autonomy, as defined by MASS, where seafarers are onboard the ship to operate and manage the ship's systems and functions, some operations may be automated and occasionally unsupervised, but seafarers are ready to take control. This situation conflicts with the requirements for navigation as stipulated in SOLAS V/14 and STCW Chapter VIII, Part 4.1, which state that "at times the ship may be unsupervised." This statement regarding watchkeeping in the bridge highlights a significant difference between current conventional ships, where automated systems on board may primarily be responsible for navigation for specific periods in the bridge, and whether a degree of MASS can comply with COLREG as it currently stands (IMO, 2018).

Rule 5, for instance, states that "every vessel shall at all times maintain a proper lookout by sight and hearing." The question arises whether automated systems can be considered a proper lookout. This is not explicitly mentioned in COLREG, which likely did not anticipate this circumstance when it was drafted, and human-centric principles are at the core of this convention (Hannaford et al., 2022; Chircop, 2019).

Within the framework of the second level of autonomy, which involves the remote control and operation of a ship from a different location, the primary point of contention lies in the varying interpretations of the role of seafarers on board a Maritime Autonomous Surface Ship (MASS) when it is being controlled and operated from a remote site. There are concerns about how seafarers can assume control and manage the ship's systems and functions and how this process will be regulated. Another concern is the challenges of interpreting and responding to signals transmitted through remote control and operation, particularly when analyzing and transmitting sound signals. At the same time, seafarers are always present on the ship but not on the bridge (IMO, 2019). Therefore, information transmitted to the remote-control center must adhere to COLREG regulations. An observed potential solution involves utilizing the Automatic Identification System (AIS) as a substitute for the obligatory sound signals.

In the third and fourth degrees of autonomy, where the ship is controlled and operated from another location with no seafarers on board, this represents a significant change for the industry, and several potential issues requiring clarification have been noted. This includes the possibility that unmanned MASS could be constructed differently from traditional ships, requiring a separate section in the appendices similar to Annex I/13 for high-speed crafts (IMO, 2017). Annex IV also posed significant challenges regarding the ability of unmanned MASS to signal distress, requiring further clarification and discussion. Questions have arisen concerning whether a remote operator can assume the role of "master or crew" and whether the remote operator can meet the same standards required as a watchkeeper on board, especially under challenging weather and sea conditions, and their ability to detect smaller vessels that Radar and ARPA may struggle to identify. Another issue pertains to the need for continuous communication between the remote operator SCC and the ship itself, where disruptions or loss of communication could directly prevent the remote operator from maintaining a "proper lookout." This also applies to Rule 19, "Conduct of Vessels in Restricted Visibility," necessitating further clarification (Hirst, 2020).

Within the framework of the fourth degree of autonomy, as specified by the IMO, there is a need for further clarification regarding the requirement of an "electronic lookout" to effectively detect, interpret, and appropriately respond to relevant sound and light signals emitted by other vessels. The significance of this technology attaining, at the very least, the equivalent standards for watchkeeping cannot be underestimated. This rule may prevent MASS operations unless it is determined that a fully autonomous ship can maintain a proper lookout using visual and auditory senses (Zhou et al., 2020).

However, it was found that the nature of Rule 6, "Safe Speed," and its requirements were not intended for application to fully autonomous ships, resulting in a gap. Rule 8, "Actions to Avoid Collision," also presented a similar issue regarding whether a fully autonomous ship could apply the principles of "good seamanship" when navigating, necessitating further research on what might require clarification or amendment (IMO, 2018). Rule 18, "Responsibilities between Vessels," by its nature, requires an understanding of the types of vessels involved, and questions have been raised about the ability of a fully autonomous ship to identify these different types of boats and act accordingly.

Rule 19, "Conduct of Vessels in Restricted Visibility," showed complexities for fully autonomous ships to understand, interpret, and adhere to the application of multiple rules requiring further discussion. Additional challenges were observed regarding terminology, lights, shapes, sound signals, compliance with maritime laws, and whether a sailboat could be considered a MASS and its interactions with other vessels and MASS.

5-2 SOLAS, 1974

The International Convention for the Safety of Life at Sea (SOLAS), 1974, commonly called SOLAS, is a global agreement establishing universal regulations for ensuring safety in maritime operations. IMO adopted this convention in 1974 and became effective in 1980. SOLAS encompasses various safety regulations about commercial ships' construction, equipment, and operation. Its primary objective is to guarantee the safety of individuals at sea. SOLAS is a vital international treaty in the field of maritime safety. It acts as a critical point of reference for regulating and improving ship and maritime crew safety on a global scale.

Chapter V, Regulation 24 of the SOLAS Convention requires manual steering control to be established during hazardous navigation. Consequently, an unmanned autonomous ship could not comply with this regulation. A general observation has been made those terms such as "master," "crew," "person in charge," and others should be clarified for the second, third, and fourth degrees of autonomy as defined by the IMO, considering the potential absence of seafarers on board. Researchers have noted that for the second, third, and fourth degrees of autonomy, definitions of "control stations" and "safety center" might need to be amended to include a remote-control center or a distant supervisory location. Additionally, the term "safety center on passenger ships" should be modified, as the safety center could be remote, and the provision of necessary safety systems functions should be available from the safety center to include automated or autonomous systems (IMO, 1974).

For the second, third, and fourth degrees of autonomy, definitions of areas where the crew is present might need to be adjusted. Since decision-making will occur remotely, either autonomously or automatically, there may be a need for additional functional requirements to demonstrate that the remote-control center or autonomous system can detect and control fires. For the third and fourth degrees of autonomy, several provisions have been identified that require manual operations and other procedures by individuals on board, such as firefighting, and some provisions related to accommodation, access, alarms, and safety centers (Pedersen et al., 2020). These apply to MASS without preventing their operation but may need amendments or contain gaps. A future issue includes evaluating risk reduction due to the absence of personnel on board (IMO, 2019).

It has been commented that unmanned shipping might not be practically applicable, as lifeboats would require a certified crew for lifeboats and personnel to assist in evacuation and possibly in firefighting. For this reason, researchers believe that operating MASS without seafarers should not be considered for passenger ships (Sharma, 2023).

Further challenges include that under the third and fourth degrees of autonomy, significant consequences could arise, particularly for cargo ships, in the event of a fire resulting in a loss of communication with the remote-control center and whether the remote location could be a continuously manned central control station. It has been investigated whether designated stations can be transferred between the remote location and the ship. Regulations may also need amendments, clarifications, or gaps concerning smoke generation and toxicity, fire detection and alarms, smoke spread control, fire containment, and notification to crew and passengers. Operational readiness and maintenance guidelines may also need to be reviewed. Existing instructions on onboard fire training and drills might prevent MASS operations. They may need complete rephrasing or amendments to identify responsible parties for fire drills other than seafarers when transporting passengers or other individuals. Other challenges relate to helicopter facilities that require firefighting personnel, potentially preventing MASS operations, and fire patrol requirements that necessitate a crew and the protection provided by portable fire extinguishers and manual firefighting equipment. There are also inconsistencies and gaps concerning post-incident safe return to port and safety areas, fire patrol requirements in passenger ships, and effective fire patrol systems for specific spaces (IMO, 2019).

The greatest challenge identified is when passengers are transported on a passenger ship or a cargo ship carrying more than 12 passengers, as the presence of seafarers on board is required to assist and evacuate these passengers in emergencies. Unless future means are developed to provide these functions autonomously, this will impede the operation of autonomous ships under the third and fourth degrees of autonomy, as the presence of certified personnel on board is essential to perform these functions.

Chapter V on Safety of Navigation considers the requirements to ensure that all ships are adequately and effectively manned from a safety perspective. There are no remote control requirements in the current regulations. Given the importance of remote control for operating autonomous ships in the second and third degrees of autonomy, new rules are necessary, particularly those related to function, design, visibility, employment, training, drills, and information transfer (IMO, 2018). Employment requirements, responsibilities, qualifications, and the necessity of having a shipmaster for autonomous ships should be revised or clarified for each degree of autonomy, especially for remotely controlled and fully autonomous ships. Current definitions in this chapter are applicable. However, gaps may exist for MASS operations, necessitating review and amendments, such as introducing a definition for MASS and other potential new definitions due to regulatory amendments in this chapter (Pundars, 2020).

5-3 STCW, 1978

The International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW), established in 1978, is a global treaty establishing worldwide benchmarks for seafarers' education, certification, and supervision. The IMO adopted it in 1978, which came into effect in 1984. The STCW convention is crucial in establishing the training criteria, abilities, and proficiencies for seafarers on global merchant vessels. The convention aims to bolster maritime safety and safeguard the marine environment by guaranteeing seafarers the necessary training and qualifications to carry out their responsibilities (IMO, 1978).

The different levels of control employed in MASS impact their capacity to adhere to specific provisions of international maritime law intended for crewed vessels. According to the previously established definition, a MASS operating under the first degree of autonomy will have a crew on board. As a result, a vessel with a crew will be required to comply with the STCW Convention, which applies to "all individuals working on ships that operate at sea." Currently, the STCW Convention does not encompass fully autonomous ships of the fourth degree. Given that the STCW Convention does not encompass fully autonomous ships, it raises the question of who is responsible for training and certifying the individuals who develop the programs that guide the decision-making of these ships. This example illustrates the lack of uniformity in MASS capabilities and the potential dangers of integrating MASS into the existing framework of international maritime law, which was initially designed for manned ships (Parker, 2021).

A review of the STCW was submitted by the United States, supported by China, Cyprus, Japan, the Republic of Korea, the Russian Federation, and Spain (IMO, 2019). The STCW Convention and its associated Code were examined simultaneously since the convention outlines the requirements, and the Code provides the standards that parties must maintain to give complete and comprehensive effect to the convention's provisions. The term "seafarer" concerns degrees of autonomy, which refers to those trained and qualified to perform the ship's operational duties and responsibilities under the STCW Convention. The term "remote operator" is understood for the regulatory exercise as the person not onboard the ship whose training and qualifications are not currently covered (IMO, 2019).

This distinction implies that amendments to the convention and the Code may be necessary to include requirements and standards for the training and qualification of remote operators, particularly in the context of MASS operating with varying degrees of autonomy. Such updates will be essential to ensure that operators controlling these ships remotely are adequately trained and qualified to perform their duties safely and effectively.

Assumptions for the third and fourth degrees of autonomy, as defined by the IMO, rely on duties and responsibilities derived from the requirements of other transport and operational agreements. For example, the STCW Convention would apply when seafarers, such as officers and engineers, on a third-degree autonomous ship conducting maintenance work. At the same time, security personnel may be on a fourth-degree autonomous ship. The regulatory application does not account for these options. The general assumption is that the "remote operator" operates and controls the ship's systems and functions. The initial review found that the convention and Code's requirements remain valid when seafarers are onboard the ship and do not apply when there are no seafarers onboard (Meštrović et al., 2023*)*.

5-4 MARPOL, 1973

The International Convention for the Prevention of Pollution from Ships, also called MARPOL, is a worldwide agreement ratified by the International Maritime Organisation (IMO) in 1973 and subsequently amended in 1978. It was officially enforced in 1983. The maritime treaty is highly ratified and encompasses six annexes that specifically target different forms of marine pollution, such as oil, hazardous chemicals, sewage, garbage, and air pollution. MARPOL implements rigorous protocols to minimize the release of pollutants from ships, serving as a vital component in worldwide endeavors to safeguard the marine environment against the detrimental consequences of human actions (IMO, 1973).

The incorporation of MASS poses numerous significant obstacles to the MARPOL Convention. A paramount concern is the restricted scope of MARPOL, which is determined by the size of the ship. Convention solely pertains to tankers with a gross tonnage exceeding 150 and other vessels with a gross tonnage surpassing 400. current MASS are below these thresholds, indicating that although they meet the general criteria of being a "ship," according to MARPOL, the convention may not apply to them. This results in a regulatory gap where smaller autonomous vessels can operate without being required to comply with MARPOL's pollution control regulations (IMO, 2024).

As the capabilities of MASS improve and their dimensions grow, they may eventually become subject to the regulations outlined in MARPOL (International Convention for the Prevention of Pollution from Ships). Nevertheless, the current convention is insufficient to meet the particular requirements of pollution prevention and response for autonomous vessels. The Conventional regulations of MARPOL do not consider the distinct operational attributes of MASS, such as their dependence on remote operators or autonomous systems. This deficiency underscores the need for customized regulations targeting the ecological consequences of autonomous maritime operations (MASS and SAR, 2023).

Another notable obstacle is the lack of clarity regarding the duties and obligations of MASS operators. MARPOL imposes specific obligations on a vessel's "captain" and "crew," positions that do not directly correspond to the remote operators or autonomous systems overseeing a MASS. The lack of clarity in this situation makes it more difficult to establish responsibility and blame in the case of a pollution incident involving a self-governing vessel. Precise guidelines are necessary to establish the specific duties and obligations of individuals who operate and supervise MASS to ensure accountability and efficient pollution management (UNCTAD, 2022).

To regulate the management of ship-generated waste under the International Convention for the Prevention of Pollution from Ships (MARPOL), it is imperative to implement targeted modifications. The proposed amendments should specifically focus on addressing concerns related to remote operations, autonomous navigation, pollution monitoring, and response to unmanned ships. The existing structure of MARPOL was not originally intended to accommodate autonomous ships, thus requiring a reassessment and adaptation of the convention to include measures that guarantee the environmental security of MASS (Parker, 2021).

Overall, the MARPOL Convention encounters considerable obstacles when overseeing pollution prevention and response for autonomous maritime vessels. These challenges arise from the convention's reliance on vessel size as a determining factor, the absence of provisions tailored explicitly to autonomous ships, and the underlying assumptions about conventional ship operations. To tackle these challenges, it is necessary to make extensive changes to the convention to align it with the technological advancements and operational realities of Autonomous Ships.

6- Results and Finding

6-1 Need for a Specialized Legal Framework

The research underscores the necessity for a specialized legal framework tailored to Maritime Autonomous Surface Ships (MASS). This framework can be achieved by amending existing international conventions, treaties, and maritime laws or establishing a new, comprehensive legal system. These autonomous ships introduce innovative technology with unique operational characteristics and risks that significantly differ from conventional ships. Therefore, specific legal provisions are crucial to regulate their operation and ensure their safety effectively. Modifying current international conventions and treaties appears to be the most practical solution, as it would provide uniformity in the legal regulations governing MASS at the international level, facilitating global compliance.

6-2 Training and Qualification Necessities

The study highlights the imperative to amend existing legislation or introduce new laws regarding the training and qualification of seafarers in remote control centers. This includes addressing the specific technology and communication systems operating autonomous ships. Figure (5), labeled "Seafarer 4.0," visually represents the essential skills and competencies required for modern seafarers operating within the context of MASS. These competencies include the digital operation of physical entities, proficiency in general digital skills, knowledge of maritime-specific computer science applications, and a solid foundation in classical maritime competencies. Additionally, skills in software engineering, coding/computer programming, and data fluency/data analytics are critical for troubleshooting, optimizing ship operations, and making informed decisions.

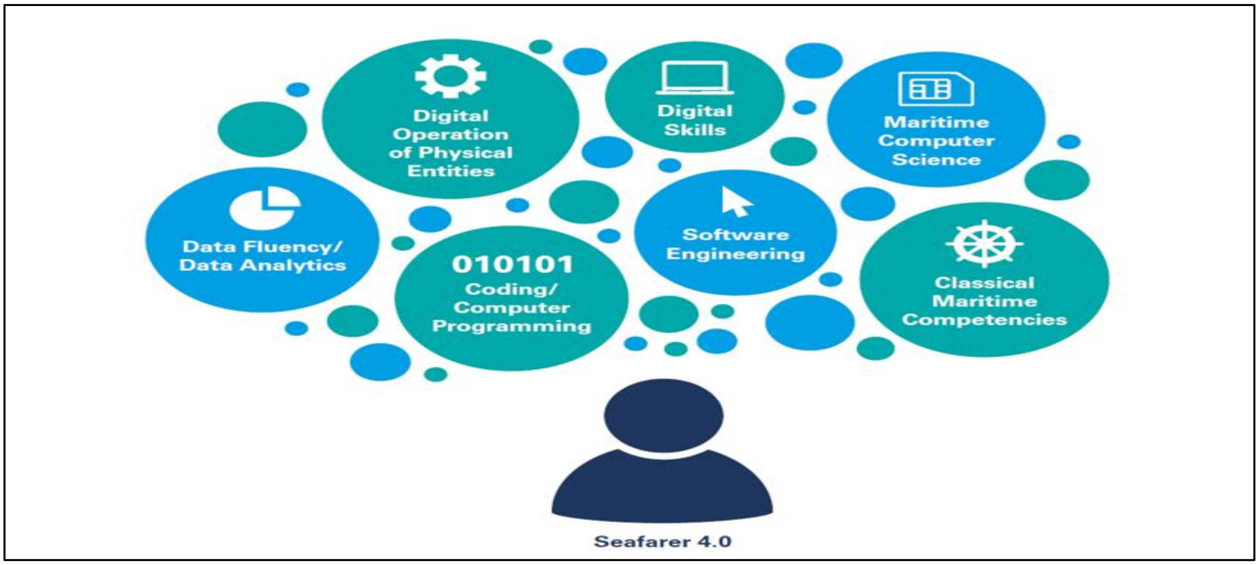

Figure 5. Essential competencies for Seafarer 4.0 in MASS

It is essential to designate a "human" master responsible for the autonomous surface ship, regardless of its operational method or level of autonomy. Depending on the technology, the Master might not need to be physically on board but must be able to intervene when necessary. A comprehensive list of the Master's roles and responsibilities, as outlined in IMO instruments and UNCLOS, should be compiled to identify which duties can be delegated to alternative parties. Integrating these advanced skills and competencies will ensure that the remote operation of MASS meets the required safety and efficiency standards. This shift in training paradigms addresses the unique challenges posed by the autonomy of these vessels, equipping seafarers with the necessary tools to manage and operate MASS effectively.

6-3 Applicability of Existing Conventions

The study meticulously considered the applicability of existing conventions, particularly the COLREG Convention. For instance, it was found that COLREG Rule 5, which pertains to "lookout" duties, explicitly refers to requirements to be performed by the "ship" rather than by a "person." This indicates that no human presence or intervention is required, and consequently, there is no need to amend the COLREG Convention as it can fully apply to autonomous ships. Additionally, the STCW Convention's requirements remain applicable when seafarers are present on an autonomous ship. However, remote operators and the Master in the Remote Operation and Control Center (ROC) are not subject to STCW requirements, necessitating the MASS Code to encompass all necessary training, certification, and competency requirements per the STCW Convention.

6-4 Environmental Considerations under MARPOL

Challenges related to the MARPOL Convention were also highlighted. One significant issue is MARPOL's size-based applicability, which excludes many more minor MASS below the tonnage thresholds. As MASS capabilities and sizes evolve, they may eventually fall under MARPOL's scope. However, the current provisions of MARPOL are inadequate for addressing pollution prevention and response, specifically for autonomous ships. Thus, MARPOL's framework must be updated to include the environmental impacts of remote and autonomous operations and to clarify responsibility for pollution incidents.

6-5 Proposed amendments and regulatory updates

The research suggests specific amendments to address remote operations, autonomous navigation, and pollution monitoring and response for unmanned ships to regulate MASS effectively. The MARPOL framework, along with other conventions like SOLAS and STCW, needs reevaluation and modification to incorporate provisions that ensure MASS's environmental safety and operational integrity.

In conclusion, the findings highlight a pressing need for a dedicated legal framework for MASS. Addressing specific operational and safety concerns through amendments to existing laws or the creation of new regulations will standardize the legal landscape for autonomous ships, ensuring their safe and effective operation within the international maritime framework. These legal advancements will facilitate the successful integration of autonomous technology in the maritime industry, enhancing safety, security, and environmental protection.

7- Research Discussion

Before considering the role of the Master of an autonomous ship, it is crucial to discuss the roles and responsibilities assigned to the crew members of MASS. Understanding these roles will clarify how the responsibilities can be distributed and managed in autonomous operations.

The Remote Operation Center (ROC) and remote operator roles should be thoroughly investigated. This includes scenarios where the ROC is located outside the flag state. Such investigations will help address jurisdictional and operational challenges, ensuring smooth and practical remote control and management of MASS.

There is a need to integrate provisions requiring MASS to assist persons in distress at sea promptly. This includes receiving and relaying distress messages, monitoring GMDSS distress frequencies, and facilitating communications related to search and rescue operations. MASS should have the necessary means and tools to transfer rescued persons onboard. Additionally, the MASS operator (RO) should be enabled to coordinate search and rescue efforts efficiently.

To keep up with technological advancements and ensure widespread understanding, it is recommended that seminars be organized focused on the technological developments related to MASS. These seminars would provide valuable information and updates, fostering knowledge sharing and stakeholder collaboration.

8- Conclusion

The continuous advancement of MASS technology is pushing the maritime industry toward a future where fully autonomous cargo and passenger ships could become a reality. This evolution necessitates significant adjustments to existing international maritime laws to ensure autonomous ships' safe and efficient integration into global shipping operations.

This research highlights the substantial challenges that MASS operations pose to current maritime legal frameworks. While the fundamental principles of significant conventions like COLREG, SOLAS, STCW, and MARPOL do not inherently obstruct autonomous ships' operation, notable gaps and ambiguities need addressing. These include defining key terms, the applicability of regulations designed for manned ships, and the specific operational and safety requirements for unmanned and remotely operated vessels.

A specialized legal framework must be developed to facilitate MASS integration into the maritime sector. This could involve amending existing international conventions and treaties or creating a new comprehensive regulatory system. Key considerations should include the training and certification of remote operators, establishing clear roles and responsibilities for autonomous ship masters, and the development of technical standards for autonomous operations.

A proactive approach by the international maritime community is essential to adapt to these technological advancements. Creating a MASS Code, similar to existing codes within conventions like SOLAS, could provide the necessary clarity and regulatory structure to govern autonomous ships effectively. This would ensure that the legal framework evolves with technological innovations, maintaining the safety, security, and environmental protection standards central to international maritime law.

In conclusion, as the capabilities of MASS continue to expand, regulatory bodies, industry stakeholders, and international organizations must collaborate in developing and implementing a robust legal framework. This will support the safe and efficient operation of autonomous ships and reinforce the maritime industry's commitment to innovation and sustainability in an increasingly automated world. The establishment of a comprehensive regulatory system for MASS will not only facilitate their integration into global shipping operations but also set a precedent for the regulation of other autonomous technologies in various sectors. Through proactive regulation and international cooperation, the maritime industry can successfully navigate the challenges posed by autonomous technology and ensure a safe, efficient, and sustainable future for global shipping.

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A Future Perspective for Digitalization of Egyptian Ports (Opportunities and Challenges) Case Study: Alexandria Port Authority

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المستخلص

برز اعتماد التقنيات الرقمية في الموانئ كتوجه رئيسي في الصناعة البحرية، حيث تسعى الدول إلى تحقيق الرخاء الاقتصادي من خلال عملية التحول الرقمي. ويتسق هذا الاتجاه مع التحرك العالمي نحو الرقمنة في مختلف المجالات. تعد الرقمنة عنصرًا أساسيًا في عملية تحويل البيئة المحيطة إلى بيئة ذكية. تتيح الإجراءات الآلية في عمليات الموانئ والتجارة ميكنة عمليات الموانئ واللوجستيات، بالإضافة إلى عمليات مراقبة الموانئ المستقلة، النقل ،الاستلام ونقل البضائع ذاتية القيادة، وخدمات التحميل والتفريغ الآلية للسفن. بالإضافة إلى ذلك، فإن اعتماد السفن المستقلة وغيرها من التقنيات المتطورة من شأنه أن يحسن فعالية الموانئ، مما يؤدي إلى تقليل الاعتماد على القوى العاملة البشرية.

علاوة على ذلك، فإن استخدام تقنيات الاستشعار والتقنيات اللاسلكية سيكون واسع النطاق في إدارة الموارد والموانئ. مثل الطائرات بدون طيار، سلاسل الامداد، مصادر الطاقة البديلة، والشبكات الذكية. الهدف من هذه الدراسة هو تحويل ميناء الإسكندرية إلى ميناء ذكي واتخاذ الإجراءات اللازمة لتحسين وتطوير كفاءة وأداء الميناء في كافة الأوجه.

بدأت الرسالة بتصنيف الثورة الرقمية إلى ثلاث عصور منفصلة، تغطي الفترة من ١٩٨٠ إلى ٢٠٢٢وسرد مختصر للأحداث الحاسمة في كل جيل وأهميتها و التحديات التي واجهتها، والتقدم العلمي المحرز وتقنيات معالجة البيانات المستخدمة في كل عصرمع توضيح الغرض من تكنولوجيا المعلومات. ومن أجل تحسين عمليات الموانئ وزيادة الكفاءة إلى أقصى حد. تم عرض التحليل في تأثير ونطاق كل جيل، بالإضافة إلى إجراء فحص شامل لمفهوم الموانئ الذكية.

تناقش هذه الرسالة تحول الموانئ البحرية منذ ما قبل الستينيات وحتى العام الحالي. كما تستكشف المعايير المختلفة للموانئ الذكية وأهميتها في تحسين الفعالية ومدى فعالية وسرعة الأنشطة في الميناء وجودة التكنولوجيا المستخدمة مع تطبيق الأنظمة المعاصرة والمتطورة في إطار التحول الرقمي، مما أدى في النهاية إلى اكتساب الخبرة من ميناء سنغافورة الذي يعتبر ميناء مثالي في صناعة النقل البحري، علاوة على ذلك تم عمل فحص شامل لمحطات الميناء الرئيسية والمشاريع القادمة للميناء ، بما في ذلك مشروع TUAS الواسع

النطاق. الميناء مخصص لتعزيز الابتكار والإبداع البحري. تستكشف الرسالة تأثير أجهزة الاستشعار الذكية على قدرات التتبع لدى سلطات الموانئ ومشغلي المحطات وهم مسؤولون عن تشغيل وصيانة الهياكل والمرافق المينائية والتي لها أهمية تاريخية.

استخدمت الدراسة منهجية بوكس جينكينز ٢٠٢١، من خلال المركز الإحصائي لميناء الإسكندرية، وتطبيق خطواتها على السلسلة الزمنية للفترة من ٢٠١٤ حتي ٢٠٢٣. تم تحليل بيانات عينة الدراسة في المراحل التالية: مرحلة التعرف، مرحلة تقدير النموذج، ومرحلة التنبؤ، لتوقع مستويات الأداء خلال الفترة من ٢٠٢٤ إلى ٢٠٢٨. كما تم إجراء مقارنة بين ما تم تطبيقه في ميناء جبل علي وسنغافورة وروتردام، والوضع الحالي لتطبيق الموانئ الذكية في ميناء الإسكندرية، بهدف تقديم توصيات لتحديد متطلبات تحول ميناء الإسكندرية إلى ميناء ذكي.

Abstract

The adoption of digital technologies at ports has emerged as a key trend in maritime industry, as nations endeavor to achieve economic prosperity through the process of digital transformation. This trend is consistent with worldwide movement towards digitization in various domains. Digitization is an essential element in process of converting surroundings into an intelligent environment. Automated procedures in port operations and trading enables development of advanced and automated terminals, as well as independent port control operations.

The aim of paper is to present a proposal to transform port of Alexandria into a smart port and execute necessary measures. The analysis began by classifying Digital revolution into three separate epochs, covering period from 1980 to 2022. An abridged chronicle of crucial occurrences in every generation and their importance. The challenges faced, scientific progress made, and data processing techniques employed in each era. A clarification of the purpose of information technology. In order to improve port operations and maximize efficiency, the analysis also considered the impact and scope of each generation, as well as conducting a comprehensive examination of the concept of smart ports.

The BOX-JENKINS methodology, ARIMA models and EVIEW software were used to analyze the time series for the years 2012–2021 through the statistical center of Alexandria Port Authority. The steps of this package were then applied to the study's sample data in the following stages: Identification Phase Model Estimation Phase Forecasting Phase and Prediction of Performance Levels from 2022–2026. In order to establish the requirements for Alexandria Port's transformation into a smart port, a comparison was done between the smart port application already in place at Damietta Port and what was implemented at Singapore, Tangier Med Port and Rotterdam.

Keywords: Digital Twin. Port Efficiency. The Internet of Things. Artificial Intelligence. Port performance. Smart Ports. Digital Transformation.

1- Introduction

Egypt possesses an extensive array of maritime ports, encompassing prominent commercial ports situated on both the Red Sea and the Mediterranean Sea, as well as smaller ports and several specialized ports as in Figure (1) dedicated to mining, tourism, and fishing. Egypt's extensive coastlines on the Mediterranean Sea, Red Sea, and River Nile, spanning a total of 2,900 kilometers, have a significant impact on the country's social and economic welfare due to the influence of marine activities (Saleh et al., 2006).

Figure (1): Commercial Ports in Egypt
Source: Maritime Transport Sector (MTS), (2023)

Ports and harbors are widely recognized as crucial drivers of national and regional development, serving as vital lifelines. They are purposefully designed as strategic instruments for regional development, meticulously constructed and managed in accordance with this objective. Consequently, the ports in Egypt serve not only as conventional maritime transportation hubs, but also encompass a diverse range of additional roles, encompassing aspects such as industry, distribution, logistics, and Sustainable Development actions. There has been a significant increase in the utilization and advancement of Electronic Data Interchange (EDI) in recent years. In general, a considerable number of platforms are subjected to processing within control rooms. The primary objective of these control rooms is to centralize extensive amounts of data from various departments engaged in all port operations. Consequently, the port's operational efficiency and competitiveness will be improved and can be measured.

Figure (2): Egypt's Strategy for Digitalization
Source: Ministry of Communication, (2023)

The objective of the Egyptian Maritime Transport Sector, as well as the objective of the Egyptian Political Leadership, was focused on the development of ports, digital transformation, and digitization across various domains, particularly within the Maritime Transport sector. This strategic approach aims to position Egypt as a leading player on the global stage and leverage its inherent capabilities and strategic geographical location.

2- Research methodology

The methodology of this thesis is a mixture of descriptive and comparative analytical approaches, including suitability and testing of various components of proposed platform. The study also critically assesses various performance and efficiency of global ports. It has been reached through the following tasks:

The thesis described level of efficiency and regression that happens to Alexandria Port due to lack of experience in coping with technological development. Also, describing criteria and standardization that global ports perform and evaluate its results and gathering data using primary and secondary data.

3- Generation of ports

The development of seaports, especially those that handle containerized cargo, results in the establishment of an increasingly intricate web of relationships between the supply and demand sides of the port services industry. The significance of seaports could be stated by grouping them according to a specific port generation. Ports of the first, second, third, and fourth generations can be identified in line with the UNCTAD model. The local community and port users (customers) were proposed as two stakeholder groups to be included in the fifth-generation port in 2011.

In 1990, the United Nations Conference on Trade and Development (UNTACD) put forward a conceptual framework for categorizing seaports. This framework considers factors such as the port's development strategy, the variety of services it offers, and the extent to which information technology is integrated into the entities operating within the port services market. This text aims to summarize the evolution of seaports before the 1960s, followed by the widespread implementation of containerization in the 1970s.

Subsequently, seaports experienced further growth in the 1980s due to the adoption of advanced technology, efficient machinery, computer systems, and intermodal operations. As per the UNTACD classification, only the biggest seaports in the world, situated at the intersection of major shipping routes, have the capability to operate as integral components of highly advanced global logistic platforms. These platforms handle a significant portion of the total cargo flow.

Table (1) displays the ports generations model proposed by UNCTAD.

Port characteristics	**1st generation**	**2nd generation**	**3rd generation**
Development period	prior to 1960	1960-1980	after 1980
Main cargo	Semi-bulk cargo	Dry semi-bulk cargo and liquid bulk cargo	Bulk, general, and containerized cargo
Attitude and strategy of port development	Conservative, means of transport change point	Expansive, transport, industrial, and commercial centre	Commercial, logistic-distribution centre for international trade
Scope of operations	[1] Loading, unloading, storage, navigation services	1 + [2] Cargo processing, industrial and commercial services - territorial expansion	1 + 2 + [3] Cargo and information distribution, logistic operations

Organisational features	Independent operations within the port, informal connections between the port and its users	Closer ties between the port and its users. No connections between different types of operations within the port, provisional ties between the port and the city	Unified port community. Port integration with the transport-commercial chain. Close connections between the port and the city. Extensive port organisation.
Specific production features	Cargo flow, simple, single services. No/low added value	Cargo flow, cargo processing. Various services, higher added value	Cargo and information flow. Cargo and information distribution. Wide package of various services. High added value
Deciding factors	Work/capital	Capital	Technology, know-how

Figure (3): Port marketing and the challenge of the third-generation port
Source: UNCTAD, (1995)

3-1 First generation of seaports
According to UNTCTAD, the primary characteristic of the first-generation seaport is the straight forward process of moving cargo between land and sea-based transportation methods, known as stevedoring. The seaport functions independently from transportation and commercial activities.

By leveraging its dominant position in the local market and frequently enjoying a monopoly, it is not obligated to make efforts to fulfil the users' needs. The first-generation port's information, document, and statistical system operates independently from the port users. The relationship between the harbour and the port city is sufficiently flexible that there is no requirement for both entities to coordinate their plans for spatial development.

3-2 Second generation of seaports
According to UNCTAD, the second-generation ports are connected to their surroundings through their transportation, industrial, and commercial functions. Industrial parks are established within port regions to handle imported raw commodities transported by sea, including iron ore, steel, crude oil, aluminium, paper pulp, artificial fertilizers, sugar, flour, and other agricultural goods.

3-3 Third generation of seaports
The development of third generation seaports occurred in the 1980s during a period of rapid growth in containerized cargo volumes, the establishment of intermodal links, and the growing

demands brought about by the expansion of international transportation. These generations exhibit greater activity levels compared to previous ones, as they actively seek for cargoes by pursuing a development plan that promotes the establishment of integrated logistics centers and logistics platforms that facilitate international trade.

Third generation ports in the operational region are distinguished by their extensive range of services, encompassing four distinct sectors of commercial activities. The first category includes the provision of stevedoring, storage, and navigation services, utilizing advanced technologies, efficient organization and effective management.

3-4 Evolution of fourth generation of port

In 1999, UNCTAD introduced the concept of a fourth-generation port. The evaluation has taken into account the following factors: the standard of port services, the use of information technology, the advancement of the port community, the existence of a port cluster and logistics center, the quality of linkages with the inland areas and the coastal areas.

Unlike the third-generation ports, the fourth-generation ports have a significant function as a hub, serving as the primary regional port from which cargo is delivered by sea to smaller outlying ports. Port authorities can be linked together through a shared administration, as seen in the example of ports in Copenhagen and Malmo, or by a shared operator for the container terminal. UNCTAD highlights those investments in port-hubs are typically carried out by the private sector, particularly by robust international firms that specialize in managing port terminals, primarily those dedicated to container operations.

4- Milestones of Digital Transformation in ports

The exchange of information is as important to freight movement as the movement of the cargo itself or the equipment that is moving it. In freight transportation, if information does not move, cargo does not move. The more seamless the information flow is, the quicker cargo can get from its origin to its destination.

Electronic Data Interchange (EDI) communications facilitate the smooth handling of cargo from mode to mode, as well as automating billing, data entry, tracking functions, and other information exchanges such as cargo manifests, vessel arrival times, inbound movements, and status notifications.

Within context EDI can reduce cycle times, forward documents, improve inventory management, plan schedules, and make purchases, in an electronic and automatic way as in Figure (4).

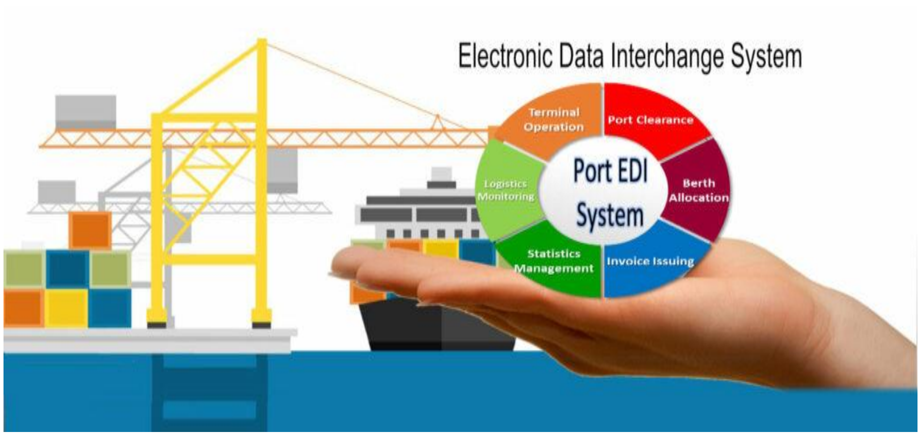

Figure (4): Electronic Data Interchange
Source: Myanma Port Authority,2023

5- Smart Port Concept

Irregular endeavours have been undertaken to build a smart port. Nevertheless, there is currently no universally recognized and standardized definition for the term "smart" within the context of ports
and the marine industry. Tracing the etymology of the word "smart" in related domains helps. assists us in comprehending the reasons for the emergence of this word.

Within the realm of technology, "smartness" pertains to the inherent ability of a system to perform autonomous computing functions, including self-configuration, self-protection, self-healing, and self-optimization (Spangler et al., 2010).

Smart growth began in the 1990s as a response to worsening trends in urban planning, such as the loss of open space, air pollution, destruction of historic locations, traffic congestion, and rising costs of public amenities that was driven by both government and society.

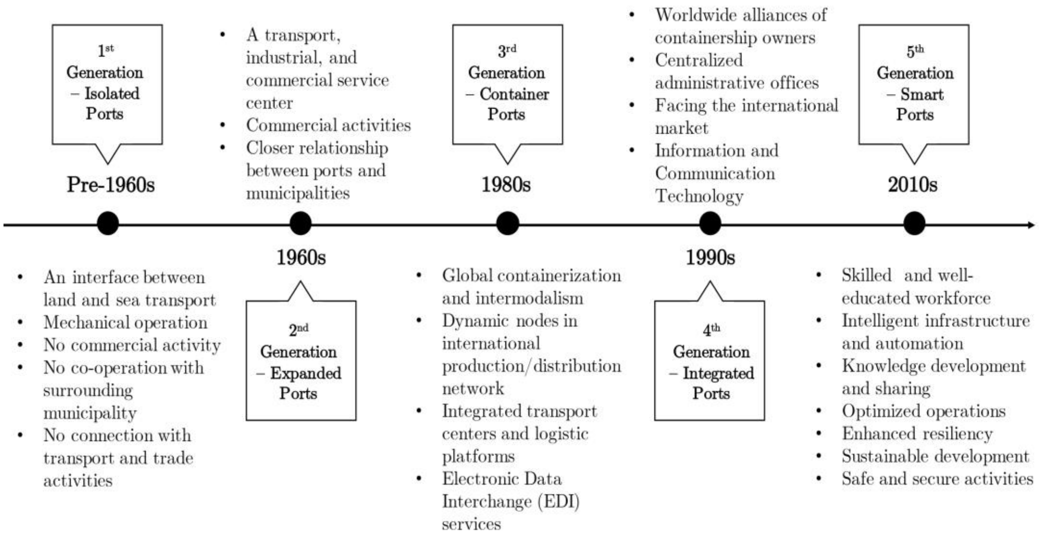

Figure (5) Ports development throughout the history
Source: (UNCTAD 1992, 1999)

A smart port brings together highly educated professionals, skilled labor forces, advanced infrastructures, and automation to promote the acquisition and exchange of knowledge, streamline port operations, improve the port's ability to withstand challenges, promote sustainable development, and ensure the safety and security of activities. The term "smart port" has become widely accepted by both the public and business sectors as an accurate description of the current trend.

Domains	Sub-domains	Description
Operations	Productivity	The extent to which the port operations are carried out efficiently within the limits of time, budget, space, and available facilities
	Automation	Automation is the use of various control systems (set of devices that manages the behavior of other devices or systems) for operating equipment with minimal or reduced human intervention.
	Intelligent infrastructure	Intelligent infrastructure means the use of technologies, both hardware and software, in the port with the aim to increase efficiency and sustainability.
Environment	Environmental management systems	Environmental management systems (EMS) are means to help organizations to improve their environmental performance. This aim is achieved through observing and controlling port operations with regard to their environmental impacts.
	Emissions and pollutions control	Port activities and shipping industry can cause three major types of pollution: emissions to air, noise pollution, and water pollution.
	Waste management	Ports receive a noticeable amount of waste, sources of which are port activities and vessels.
	Water management	Water is a vital resource for both human and other species health, so monitoring and controlling the water quality should be part of port plans and strategies.
Energy	Efficient energy consumption	Several factors influence the energy consumption of a port. These elements could be divided into two categories, direct and indirect energy users. For both groups, saving possibilities should be identified.
	Producing and use of renewables	Renewable energy is replenishable energy that is generated from natural processes. There are significant possibilities of renewable energy implementation in the ports. This assists in partially or totally covering the port energy demand and significantly reduces pollutions.
	Energy management	Ports should identify energy management strategies and activities to make efficient use of the available energy.

Safety and Security	Safety management systems	Safety Management System (SMS) is a comprehensive business management system designed to administer safety principles in the workplace.
	Security management systems	A security management system identifies potential threats to the port and establishes, implements, monitors, reviews, and maintains all appropriate actions to provide assurance for the effective handling of security risks.
	Integrated monitoring and optimization systems	Establishing an integrated monitoring and optimization system based on the most recent software and hardware facilitates achieving enhanced security and safety in the port area.

Table (6) Classification of a smart port activity domains and sub-domains
Source: Anahita Molavi, 2019

6- Smart Port Activity Domains

Table (6) outlines that a smart port is comprised of four primary activity domains: operations, environment, energy, and safety and security. Port performance can be evaluated by analyzing quantifiable components known as "sub-domains" of a smart port. These sub-domains will be further elaborated upon.

6-1 Operations

A smart port employs advanced technologies and implements new and efficient management methods to enhance the efficiency of port operations and reduce associated expenses. The sub-domains encompassed within smart port operations are productivity, automation, and intelligent infrastructure.

6-2 Productivity

According to Statistia (2017), the global capacity of containerships will expand by 1,685,187 TEUs or 8% by 2019. This high growth rate highlights the need of boosting port productivity, since it hasa significant impact on a country's overall productivity. The assessment of port operation productivitycan be conducted by measuring productivity in seven specific areas: berth productivity, infrastructure productivity, land productivity, capacity for accommodating large vessels, utilization of maximum capacity, level of intermodality, and the number of lines calling at the port (MedMaritime SMART PORT, 2016).

6-3 Automation

Automated machinery has the potential to replace human workers in ports, resulting in a decrease in human errors, safety concerns, port congestion, and turnaround time. Additionally, it can improve operational efficiency in port operations (MedMaritime SMART PORT, 2016).

6-4 Intelligent Infrastructure

Integrating advanced hardware and software systems at ports can enhance operational efficiency and sustainability through the real-time collection, analysis, and dissemination of data. Port users should have access to information regarding the traffic flow of both vessels and hinterland transportation vehicles, closure times of movable bridges, and other infrastructure details.

7- Levels of Transformation into a Smart Port

In order to establish a smart port, there are four distinct degrees of specific actions involved in the process of digital transformation (Figure 7). A port is an intricate system, and modifying one of its components does not automatically make the entire port smart. Instead, a comprehensive digital transformation must occur at these four levels to accomplish this objective.

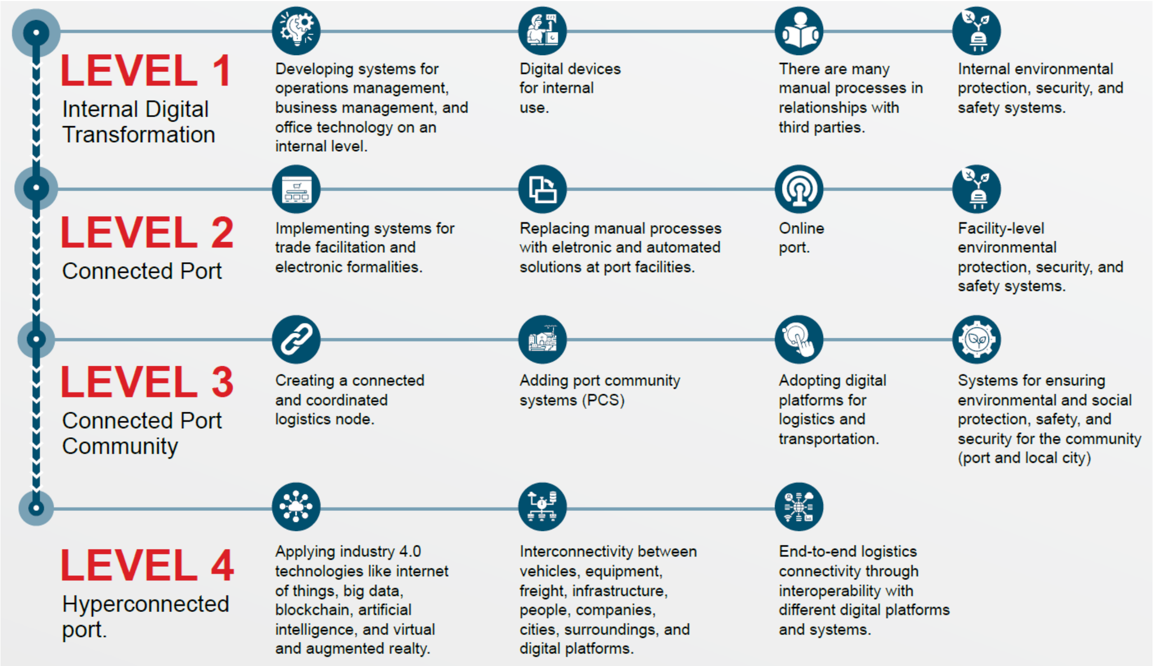

Figure (7) Levels of Transformation into a Smart Port
Source: smart port manual strategy and roadmap

8- Applications of Information Technology in Ports

An intelligent port is characterized by its integration of several 4.0 technologies such as sensors, robotics, Radio-frequency Identification (RFID), IoT, and Big Data. These technologies would significantly improve the port's problem-solving capabilities. In summary, the port operation would be enhanced and the management of the port will be simplified with the implementation of 4.0 technologies. To facilitate quicker and more accurate decision-making in real-time, the Automatic Identification System (AIS) was implemented.

9- Importance of transforming ports to smart ports

The process of digitalization has revolutionized our society, and ports have not been exempted from this transformation. The process of digitizing ports has given rise to what is commonly referred to as ports 4.0, a novel era of smart ports that leverage technology to enhance their operational effectiveness and output.

Ports 4.0 are technologically advanced ports that utilise intelligent systems to enhance their operations and provide more efficient and sustainable services. The port industry revolution is centred around the digitization and integration of various technologies to enhance the efficiency of cargo handling operations.

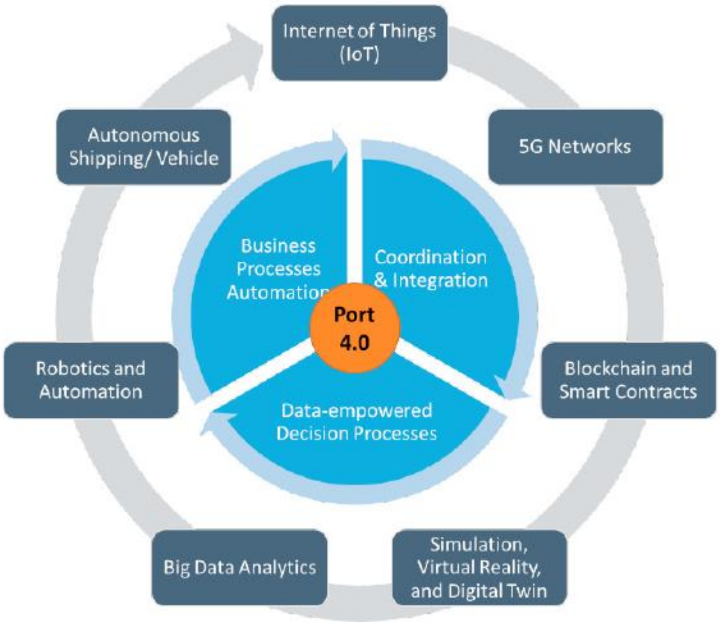

Figure (8) Conceptual Model for Port 4.0
Source: Behzad Behdani.(2024)

10- Port of Rotterdam (Case Study)
In the 14th century, the Rotte was a little fishing village located along the Rotte river. Over the course of six centuries, it has transformed into the largest and most significant port on the continent, and indeed, in the entire globe. Over the course of the previous century, Rotterdam has experienced significant and quick growth, transforming from a modest fishing village into the primary port in Europe.

Implementing automation for each party involved in the port facilitates the gathering of data. This can be utilized to enhance the cost-effectiveness, safety, and sustainability of the port. The introduction of the PMS in Rotterdam has reduced the time it takes for ships to complete their operations by 30 minutes. Given that the cost of a vessel is €10,000 per hour, the total annual savings for the entire port of Rotterdam would amount to approximately €150 million. Decreasing the number of incidents leads to annual savings of €7 million. By optimizing the deployment of port staff, annual savings of €2 million can be achieved. For example, it is evident that despite the growth of Maasvlakte 2, the workforce of the Harbour Master's Division has decreased. The PMS in the port of Rotterdam yields an annual save of around €160 million.

11- Singapore port (Case Study)

Singapore has created and implemented the following advanced technologies and intelligent systems: Firstly, secondly, thirdly, fourthly, fifthly. The Next-Generation Vessel Traffic Management System (NGVTMS) utilizes data analytics and machine learning to detect areas of high traffic and employs advanced algorithms to forecast probable collisions. The VHF Data Exchange System (VDES) enables secure and dependable data transmission between ships and between ships and shore. digitalPORT@SG™ is Singapore's Maritime Single Window, a comprehensive platform that facilitates port call transactions and regulatory clearance. The Singapore marine Data Hub is a comprehensive platform for sharing data that facilitates secure exchanges of information to stimulate the creation of creative solutions for the marine industry. DigitalOCEANS™ is a digital platform that seeks to enhance the compatibility between different systems in the global maritime transport chain. It achieves this by creating common data standards and Application Programming Interfaces (APIs) specifically for the maritime industry.

Singapore's marine research and development is advancing according to the 'Singapore R&D Roadmap 2030 - marine Transformation'. This roadmap is based on five main strategic research focuses: i) A highly productive and advanced port of the future, ii) Strategic management of sea space and maritime traffic, iii) Intelligent fleet operations and self-driving ships, iv) Reliable maritime safety and security, v) Ensuring a sustainable marine environment and energy sources. The Port of Singapore is implementing a strategic smart port initiative known as 'NGP (Next Generation Port) 2030'.

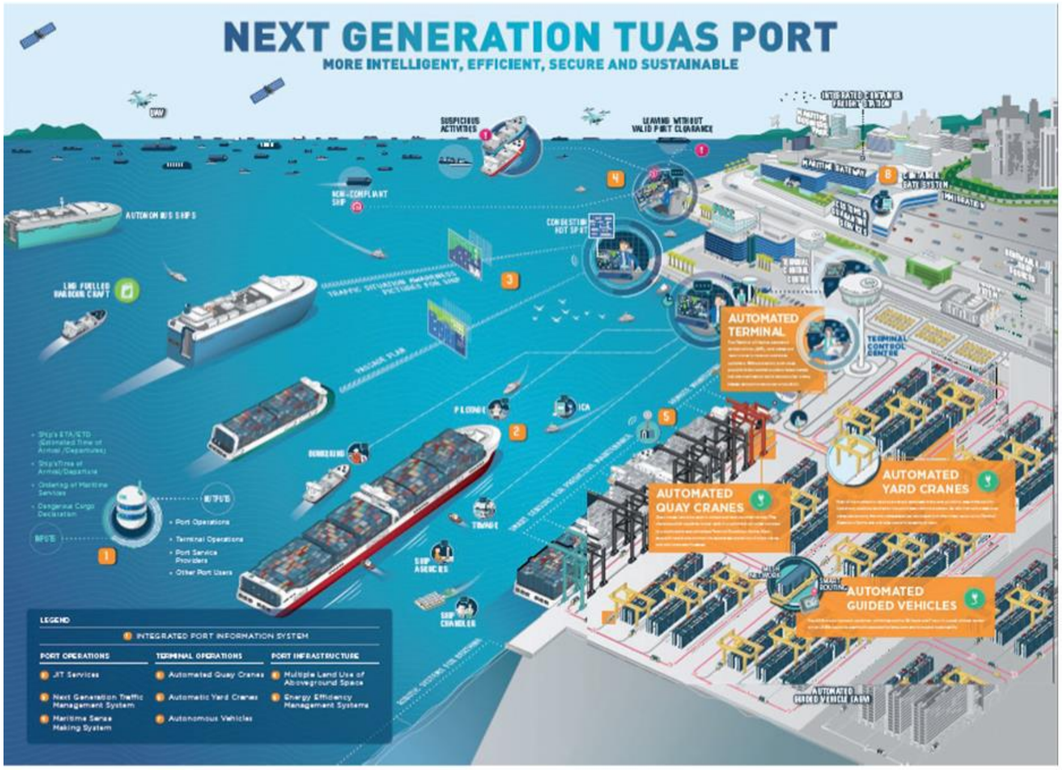

Figure (9): Singapore’s next generation port
Source: Smart Digital Ports (2019)

The NGP 2030 program serves as a framework for the comprehensive strategic planning and growth of the Singapore port. It encompasses the creation, design, and execution of the Tuas terminal, Tuas marine center, and port operations. The subsequent are the principal strategies: This text consists of a series of bullet points. Efficient and proficient administration of harbor waters Enhance the level of security and ensure safety Improve the overall experience of port users Enhance the long-term viability and conservation of natural resources and ecosystems. Singapore's Roadmap 2030 intends to enhance research and development (R&D) efforts and allocate resources more effectively to foster increased collaboration and innovation in the maritime industry.

12- Alexandria Port's efforts in digital transformation

Digital transformation aims to optimize the efficiency, boost the effectiveness, and ensure the long-term viability of logistics services. Additionally, it effectively decreases expenses and facilitates additional advancements to ensure that the port is interconnected with diverse sectors, encompassing the handling of cargo, transportation logistics, and the movement of goods. This integration enables seamless collaboration between ships, cranes, containers, and trucks, resulting in proficient operations within the port.

Alexandria Port aims to become a smart port by utilizing digital transformation solutions, improving infrastructure, and providing training to port personnel as in figure (10). Alexandria Port actively engages in international forums focused on digital transformation.

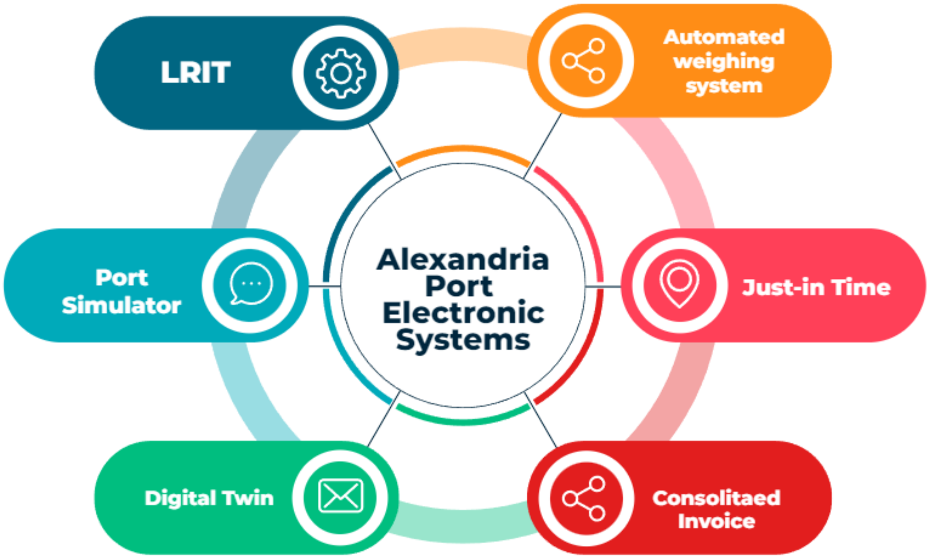

Figure (10): Alexandria Port Economic systems
Source: developed by the author

13- JIT (Just in Time) System for ships

An efficient method designed to complete all necessary tasks within the specified deadlines. By implementing this system in ship operation process, the ship that is arriving at the port will receive precise information regarding the designated time for mooring. Similarly, the ship that is already moored will be notified of the exact time for departure. The objective of this method is to minimize the duration of the ship's waiting period prior to entering port. This system will minimize detrimental emissions to the environment while also decreasing operational expenses.

Figure (11): Benefits of Just-in time system
Source: Teqplay website (Online)

14- Digital Port Twin

A digital port twin is a computer-generated model that accurately simulates a physical port, encompassing its infrastructure, equipment, and operational activities. This method employs data, sensors, and real-time three-dimensional models to generate a precise digital representation of the port. A digital twin refers to a virtual replica or representation of a physical object, system, or process. It encompasses a comprehensive digital model that captures the characteristics, behaviour, and functionality of the real-world entity it represents.

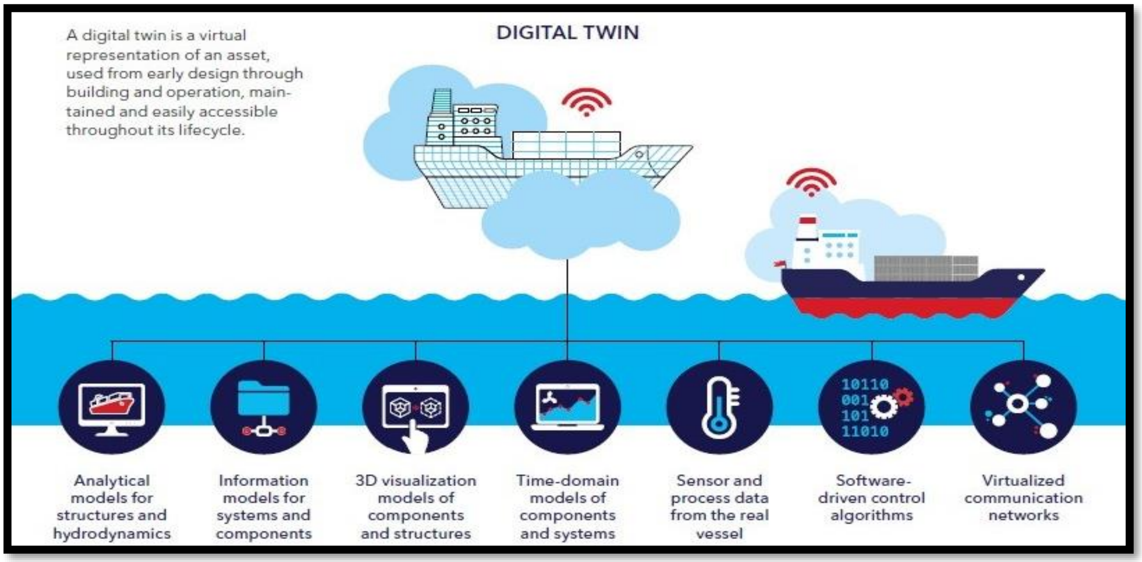

Figure (12): Digital Twin system overview
Source: Arash-Javadi (Online)

15- Smart Port Solution (SPS)

The SPS system's objective is to automatically generate invoices immediately after the completion of procedures, thereby enhancing and augmenting the port's efficiency in relation to its clients. The system is designed to incorporate rules, calculation categories, and variables (such as sunrise and sunset times) in a dynamic manner, enabling their modification without the need for programmatic intervention.

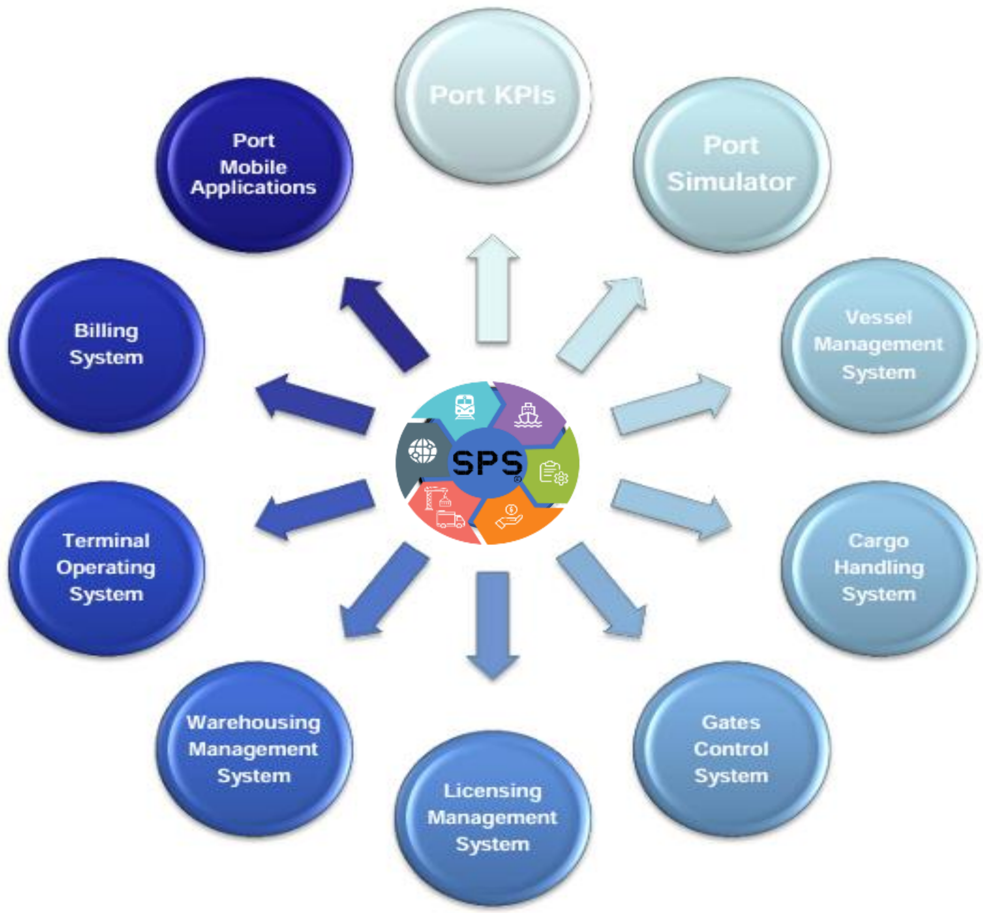

Figure (13): SPS system architecture
Source: Alexandria Port Authority

16- Future perspective for the digitalization of Alexandria Port

In order to facilitate the smart transformation of Alexandria Port Authority, a comprehensive development plan was devised based on an analysis of successful international ports like Rotterdam and Singapore. By identifying the disparities between the achievements of Alexandria Port Authority and these global counterparts, the study formulated a proposal. The digital transformation process, as depicted in Figure (14), encompasses three distinct levels: internal transformation, port community transformation, and intelligent transformation.

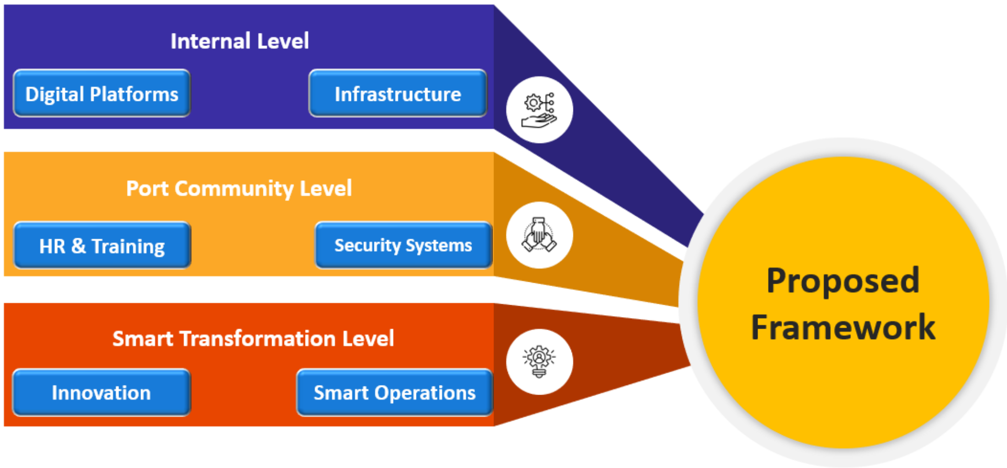

Figure (14): Proposed development of Alexandria Port Authority
Source: developed by the author

17- Conclusion

The objective of this study is to delineate the fundamental duties carried out by smart ports, including the smart ship industry, 5G connectivity, transport automation, and smart containers. Moreover, it provides a representation of the intelligent port concept and emphasizes the essential cutting-edge technologies that form the foundation of these ports.

Several academic and practical research projects have proposed innovative methods to simplify port operations. Notable examples include the Erasmus Smart Port in Rotterdam, the Netherlands, and the Smart Port of Hamburg in Germany.

A smart port refers to the complete automation of all port operations, as well as the real-time communication of all port activities through the automatic transmission of mobile data. This results in a twofold increase in the capacity of ports to carry out and combine port operations.

Hence, the intelligent port optimizes efficiency by streamlining administrative processes and cutting labor costs, while also enhancing monitoring and traffic management capabilities, so alleviating congestion, boosting production, and ensuring worker safety.

A smart port comprises a fusion of sensors, actuators, wireless devices, and database processing centers. This enhances the efficiency and resilience of the services offered by port authorities in a more sustainable manner. The smart port utilizes many key sensors to gather relevant data, including eddy current sensors, ultrasonic sensors, image sensors, inertial sensors, radio frequency identification (RFID), and radar.

Although the ethical and moral perspective of this research is significant, the study serves as a fundamental starting point for developing an effective and unique strategy for the Alexandria Port Authority. Furthermore, to address the clear disparity in the adoption of smart port applications between the international and regional levels.

This research proposed a modern framework for implementation of smart port processes that considers a step toward improving the rank of Alexandria port. The proposed modern framework is based on state-of-the-art technology in the field of smart port applications worldwide. In terms of technology, many modern technologies have invaded IOT, Blochchain and Digital Twin in the last five years. Such great jumps in IT, electronics and communication technologies happened in recent decades, and many advanced technologies have invaded the ports globally.

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Seaworthiness of autonomous vessels and remote operation center in the context of marine insurance

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المستخلص:
كانت صلاحية الإبحار قضية هامة في التأمين البحري منذ القرن الثامن عشر في القانون الإنجليزي. حالياً، تقوم المنظمة البحرية الدولية (IMO) بإعداد قانونMASS ، الذي يُعتبر بموجبه مراكز التشغيل عن بُعد امتدادًا للسفينة، حيث يقوم الأشخاص الذين يشكلون طاقم السفينة المستقلة بالتحكم في السفينة عن بُعد من الشاطئ. هذا يغير الصورة القانونية الحالية تمامًا مقارنة بالقوانين السابقة التي يعتمد عليها القانون الإنجليزي. ومع ذلك، فإن خطة التأمين البحري الإسكندنافية لم تطبق مفهوم صلاحية الإبحار منذ عام ٢٠١٣، وتعمل فقط بمفهوم اللوائح الخاصة بالسلامة. تقارن هذه المقالة بين هذين النهجين السائدين في أسواق التأمين البحري اليوم. تختلف ردود فعل المؤمنين في ظل هذين النظامين القانونيين بالنسبة للشحن المستقل، الذي سيكون واقعًا في حركة النقل الدولية اعتبارًا من عام ٢٠٢٥، عندما يدخل قانون MASS غير الإلزامي حيز التنفيذ تحت اتفاقية.SOLAS

الكلمات المفتاحية: التأمين البحري، صلاحية الإبحار، اللوائح الخاصة بالسلامة.

Abstract
Seaworthiness has been an important issue in marine insurance since 18th century in English law. The IMO is currently preparing the MASS code under which remote operation centers are considered as an extension of a ship as the persons which form the crew of an autonomous vessel are onshore navigating the vessel from distance. This changes the existing legal picture completely in relation to the previous case law in which the English law is based on. However, the Nordic Marine Insurance Plan has not applied the concept of seaworthiness since 2013 and only operates with the concept of safety regulations. This article compares these two approaches which are dominating the marine insurance markets of today. The reactions of the underwriters are very different under these two legal regimes in relation to autonomous shipping, which will be a reality in international traffic since 2025 when the non-mandatory MASS code enters into force under the SOLAS.

Keywords: MASS, SOLAS, Marine Insurance, Seaworthiness, Safety Regulations.

1- Introduction

Remotely controlled vessels can be controlled either from another vessel (mother ship) or from a remote control centre. According to the draft MASS code currently being prepared, fully autonomous vessels (IMO level 4) will also be continuously monitored either from a remote control centre or from the mother vessel so that they can be transferred to active remote control if the situation so requires. Different names have been used in the literature for remote control centres, but in the preparation of the MASS code, the terminology has been confirmed by referring to them as Remote Operation Centres, or ROCs.

In terms of seaworthiness, defining the status of the remote control centre as part of the whole is a relevant question as part of marine insurance as a whole. If the remote control centre is located on land, the question to be resolved is: what is the legal relationship between the ROC and the seaworthiness of the ship? The question has been raised by several legal scholars of whether, for example, the incompetence of the remote-control operator or structural problems with the ROC would make the vessel unseaworthy? If the ROC is considered an extension of an autonomous or remotely piloted ship, the manning, design and maintenance of such centres can inevitably play an important role in determining the seaworthiness of the ship.

The MSC 108 working group preparing the MASS code unanimously decided to propose this interpretation by recording it as "ROC is an extension of the ship (i.e. company and flag have oversight over a ROC)". In the light of current regulation and case law, this entry – if it is no longer amended when code 2025 is finally adopted – means that the insurer could also question the seaworthiness of the remote control centre and refuse insurance compensation on that basis. In the absence of case law in this regard, interpretation will have to be awaited from the English courts.

Two business models have been proposed in the preparatory work for the MASS Code, the first of which is that a shipping company/operator owns and operates a centre for the control of several vessels in its fleet, or the independent ROC provides services to various shipping companies as an independent contractor. During the preparation of the MASS code, it has become clear that the supervision and certification of such centres will be the responsibility of the flag State of the vessel, even if vessels flying more than one flag are operated from the centre.

2- ISM Code as a model for MASS Code and ROCs

There has been discussion about whether the ISM code can also be used as a model for ROC acceptability certificates. In any case, the MASS working group in May 2024 continued to take as its starting point a solution whereby each flag State whose vessels are controlled by the remote control centre in question must audit the centre for the operation of its own vessels. The emphasis on the role of the flag State in the control of ROCs is thus comparable to the control carried out on conventional ships with regard to their ships and bridge, and with regard to the ISM code, both with regard to the ship and the safety management system of the company. Thus, from an operational point of view, it is difficult to find grounds for not considering a unit that plays a key role in the navigation of a ship as part of that unit for determining its suitability to navigate at sea.

However, prior to May 2024 and the discussion of the MSC, there has been no consensus among the countries involved in the IMO work on this issue, and some of those looking at the matter from the point of view of English law have previously considered the seaworthiness of the remote control centre to be too far-fetched and considered that the seaworthiness requirement cannot be extended to a land-based remote control centre. As is often the case in the preparation of international conventions, only time pressure to conclude an agreement will lead to a consensus between the parties.

3- Nordic Marine Insurance based on Safety Regulations

The Nordic Marine Insurance Plan has not applied the concept of seaworthiness since 2013 and only operates with the concept of safety regulations.

Safety regulations related to marine insurance mean that the insured must comply with certain requirements aimed at reducing the risk of accidents. If the insured violates these requirements negligently, and the violation leads to an accident, the insurer is exempt from liability. Since the concept of safety regulations incorporates most of the existing provisions affecting ship safety directly into the marine insurance contract, this is a very important tool for improving maritime safety.

The concept of safety regulation in the context of insurance is a Scandinavian invention and does not apply to other insurance schemes. E.g. The English ITCH terms and conditions do not contain rules that directly concern the insured person's obligation to comply with safety legislation.

A Safety regulation is a loss prevention order issued by an authority, provided for in an insurance contract required by an insurer on the basis of an insurance contract or issued by a classification society.

From the point of view and perspective of the Nordic law, the matter concerning the personnel of the ROCs of autonomous vessels is simpler, because the protection guidelines can be applied to both land-based and sea-based activities on the basis of Nordic insurance contract laws. As explained above with regard to the ISM Code, it is equally regarded in the Nordic countries as Safety regulations in the insurance clauses are linked to both the ship's and the company's safety management system, the violation of which may result in loss of compensation. As such, this Nordic model is also suitable for use in connection with autonomous vessels and their remote control centres. In the English system, the current insurance conditions do not lend themselves to this as such.

4- ROC personnel and the new risk regime in autonomous shipping

Turning our attention to the staff working for ROCs and looking at the extent to which they are covered by the standard cascade insurance clauses of the English system, it is clear that adding ROC to the equation introduces new risk factors that are understandably not addressed by current insurance clauses. In this context, the obvious question is whether the loss caused by RCO's 'negligence' is recoverable. Conventions and national regulations lay down requirements for the qualifications and training needs of the staff of such centres for conventional ships, but there is a legal vacuum in this respect for legally autonomous ships. This vacuum also needs to be resolved before such ships are put into service, but the MSC has still not given a mandate to the working group currently reforming the STCW Convention, because it has hitherto been considered premature. The problem with the STCW Convention is that it applies exclusively to work on board ships. It is still unclear where and how questions concerning the qualifications of ROC employees will be regulated.

5- Conclusions

The Work of MSC regarding the MASS Code continues during autumn 2024 and the voluntary MASS Code will be accepted in the spring 2025. Many countries are expected to begin with national and international traffic with autonomous vessels when it enters into force. The technology has been ahead of the legal regime for a long time and the lack of seafarers in several countries is leading to increased autonomy in near future. This article has raised the question how the problem with traditional seaworthiness regime in marine insurance context will be handled. The English marine insurance law still demands that the vessel has to be seaworthy in order to be entitled to compensation when the vessel is lost or damaged. The Nordic Marine Insurance Plan does not apply the seaworthiness demand, but instead it follows the Safety regulation regime established in Nordic Marine Insurance law.

Especially the relation of the ROCs personnel concerning the issue of seaworthiness and safety regulations is an issue which will come to the spotlight when the owners of MASS vessels are choosing their insurance regime. If I would be the owner, I would choose the regime which clearly applies to the issues raised by the new situation where the personnel of the vessel are situated in the ROCs on land instead of a bridge at sea. It is expected that also English law will be adjusted to the new situation with several new clauses in the insurance contract. But still the legal precedents concerning seaworthiness in the English legal system might raise some doubts how the clauses will be interpreted. The English legal system has shown that it can adjust to changes. However, the changes are nowadays faster than ever when the long-awaited regulation of MASS vessels is to be implemented. Therefore, my conclusion is that the Nordic Marine Insurance Plan has a clear advantage in this respect when compared to the English hull clauses.

Assessment of the lost cargo capacities of a container vessel when transitioning to alternative fuels

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المستخلص:
تمثل الوقود البديلة حلاً قابلاً للتطبيق لتقليل الانبعاثات الكربونية في صناعة الشحن البحري. هناك العديد من الخيارات المتاحة، حيث أن بعض التقنيات ناضجة وجاهزة للاستخدام، في حين أن تقنيات أخرى ما تزال قيد التطوير. ومع ذلك، من المؤكد أن الوقود البديل والتقنيات الأحدث يمكن أن تحل محل الوقود التقليدي. التحول إلى الوقود البديل يأتي بتكلفة، حيث تتمثل بالنسبة للسفن التجارية في فقدان مساحة الحمولة بسبب كثافة الطاقة العالية للوقود البديل مقارنة بالوقود الأحفوري. تحسب الدراسة الحالية تكلفة فقدان الحمولة عندما تستخدم سفينة حاويات بسعة ٨٠٠٠ وحدة مكافئة للحاويات (TEU) الميثانول والأمونيا كوقود. وقد لوحظ أن المساحة الإضافية المطلوبة للميثانول تبلغ ١٦٧٤ مترًا مكعبًا، بينما للأمونيا تبلغ ٢٢٧٧ مترًا مكعبًا. إن فقدان مساحة الحمولة له تأثير كبير على القدرة على الكسب للسفينة طوال عمرها التشغيلي. بغض النظر عن ما إذا كان المالكون سيختارون نهج التوقف الواحد أو التوقفين، يجب على المالكون تحديد تكرار التزوّد بالوقود بناءً على مسار السفينة وإجراء مراجعة شاملة لسعة خزانات الوقود.

Abstract:
Alternative fuels represent a viable solution to the decarbonization of the maritime industry. There are several options available with some technologies mature and ready to use. Other technologies are still under development; however, it is a certainty that alternative fuels and newer technologies could substitute conventional fuels. Changing to alternative fuels comes with a price. For cargo vessels, it is the loss of cargo space, due to the higher energy density of alternative fuels compared to fossil fuels. The present study calculates the cost of lost cargo when an 8000 TEU container vessel is burning methanol and ammonia. It is noted that additional cargo space required for methanol is 1674 m^3, while for ammonia is 2277 m^3. The cargo lost space has a significant impact on the earning potential of the vessel throughout its lifetime. Regardless of whether the owners choose a one-stop or two-stop approach, the owners must determine the frequency of bunkering based on the vessel's route and conduct a thorough review of the fuel tank capacity.

1- Introduction

Maritime transportation is responsible for 3% of the total GHG emissions worldwide. To reduce the impact on the environment, the International Maritime Organization has established a set of regulations and policies intended to reduce harmful pollutants. IMO's ambition is to reach net-zero GHG emissions from international shipping by 2050. There are both operational and technical solutions available and ready to use. Operational measures can reduce emissions in the short term; however, long-term solutions are new technologies and alternative fuels. New technologies include wind and solar systems, nuclear power, fuel cells, and carbon capture and storage technology. One of the most viable measures is to replace fossil fuels with alternative fuels, such as LNG, methanol, ammonia, biofuels, and hydrogen. In 2023, 98% of the ships in operation were burning conventional fuels and 26% of the ships on order will be powered by alternative fuels. Depending on the type of fuel and the energy density, the fuel tank space is larger and requires more space for alternative fuels than for conventional fuels. This transition comes with a cost. Even if the emissions are significantly reduced, the cargo space will also be affected. The space concerned depends very much on whether the vessel is retrofit or new build. In case of a new build, the vessel's design will consider all the aspects, so that the cargo space loss will be affected as little as possible. In the case of a container vessel, it depends on the type of alternative fuel, as well as the size of the vessel, the route, the bunkering facilities, or the alternative fuel infrastructure.

2- Literature review

MMMCZCS, (2022) and the partners conducted a report regarding the environmental and techno-economic analysis when converting a 15000 TEU container vessel to alternative fuels. When vessels operate on conventional fuel, a typically 6000 m^3 fuel oil is required. However, changing to alternative fuels, the most probable option is to shorten the range to reduce the tank sizes, therefore reducing the cargo space loss. The same study shows that for a 15000 TEU vessel, the lost cargo space for methanol is on average 500 TEU and an average of 700-800 TEU for ammonia fuel. Their study concluded that lost cargo space can be reduced by placing fuel tanks under the accommodation. It is also important to mention that cargo lost space is different between a new build and a retrofit. When changing to hydrogen, container vessels must either make more refueling stops or eliminate space dedicated to cargo, as hydrogen needs four times more fuel tank space than conventional fuels (Deloitte, 2023). DNV, (2023) has done extensive work on alternative fuels for container vessels, and regardless of the type of fuel, the cargo space is reduced. Various options such as increasing the frequency of the bunkering ports, different arrangements of fuel tanks, in-depth analysis of CAPEX and OPEX, and the vessel’s operational profile should be taken into account when designing a vessel powered by alternative fuel. The use of hydrogen fuel can result in a lost cargo space up to 13% for a short sea vessel (Law et al., 2022). The same authors stated that cargo space loss depends on the type of cargo, therefore fuels with volumetric density engage less with cargo storage. The loss of the cargo capacity of the vessel can restrict financial opportunities for the vessel owner and charterer (Lagemann et al., 2023).

3- Case study

The present article analyzes the lost cargo space of a container vessel when changing to alternative fuels.

For the purpose of this study, Vessel has the following characteristics:

LOA	334 m
DWT	101906 t

GRT	90745 m^3
TEU	8238
YEAR BUILT	2004
ENGINE POWER	68640 kW

For the one-year route studied, the vessel must apply operational efficiency measures defined in SEEMP III to follow the regulations and be more attractive to the charterers.

The operational measures are short-term solutions, but these options will not be applicable in the long term. Therefore, cost analysis of alternative fuels, methanol, and ammonia, will be illustrated.

CAPEX for conventional fuel, ammonia, and methanol are presented in Table 1. CAPEX values include construction costs, which depend on the engine cost with all the systems and arrangements.

Table 1. CAPEX values for power and tank (Fam et al., 2022)

Type of fuel	**CAPEX Power Value** (Euro/kW)	**CAPEX Tank Value** (Euro/kWh)
Diesel/MDO/MGO	385	0.08
Methanol	400	0.14
Ammonia	503	0.17

OPEX for a year for different types of fuels, is presented in Table 2. OPEX values mean the operational costs of the vessel – voyage costs, repair, and maintenance, insurance, stores, spares, crewing, and miscellaneous expenses.

Table 2. OPEX in 2030 for alternative fuels "adapted from (Statista, 2023)"

Type of fuel	**OPEX in 2030 (million Euro)**
HFO	15
Methanol	35
Ammonia	40

The required storage capacity of methanol and ammonia fuels compared to MGO, are shown in Table 3.

Table 3. Storage capacity of methanol and ammonia fuels compared to MGO "adapted from (Reusser & Perez, 2021)"

Fuel type	**Specific Energy (MJ/kg)**	**Storage onboard**	**Required storage capacity (m^3)**
MGO	42.7	Liquid at ambient temperature	1000
Methanol	23	Liquid at ambient temperature	2272
Ammonia	17	21°C under 8.8 bar; -33°C atm pressure	3121

The cost of lost cargo due to extra space required for the installation of fuel tanks (Fam et al., 2022) is:
For Methanol: It is assumed that for the vessel studied the cargo space lost for a fuel tank is 1 674 m3, compared with a conventional fuel tank.

For Ammonia: Ammonia has 1.36 less volumetric energy density than Methanol, thus the cargo space lost for Ammonia will be multiplied by 1.36 Methanol.
Therefore:
Additional cargo space for Methanol = 1 674 m^3
Additional cargo space for Ammonia = 2 277 m^3

$$Cost\ of\ lost\ cargo = Average\ price\ TEU \times \frac{Additional\ cargo\ space\ for\ fuel\ typy}{Volume\ TEU}$$

Considering the following:
Volume/TEU = 38.5 m^3
Average price/TEU = 1 280 Euro
Additional cargo space for Methanol = 1 674 m^3
Additional cargo space for Ammonia = 2 277 m^3

Table 4. Cost of lost cargo "adapted from (Fam et al., 2022)"

Type of fuel	Cost of lost cargo (Euro)
Methanol	55 655
Ammonia	75 703

4- Conclusions
Both CAPEX and OPEX increase significantly when changing to alternative fuels. In addition, there is the cost of lost cargo for the fuel tanks, which are considerably larger for alternative fuels than for fossil fuels. The owners must decide the bunkering frequency based on the vessel's route and perform a detailed analysis of the size of the fuel tanks whether deciding on a one-stop or two-stop strategy. Another aspect that should be taken into account is the optimal location for alternative fuel tanks. For large container vessels, it is proven that placing the fuel tanks under the accommodation can have the smallest impact on the cargo lost space. Besides the alternative fuels, vessels can choose different new technologies that can reduce emissions (wind, solar, carbon capture and storage), however, all of them have an impact on the cargo capacity of the vessel. For example, wind technologies are more appropriate for vessels that don't carry cargo on deck, such as bulk carriers or ro-ro vessels. For container vessels, alternative technologies are limited and the change to alternative fuels is proven to be the best decision.
The cargo lost space has a significant impact on the earning potential of the vessel throughout its lifetime.

When retrofitting or choosing an alternative fuel, the owners have to evaluate all strategies based on the following:

- Frequency of bunkering
- Financial assessment, financial losses due to reduced cargo capacity vs potential cost savings
- Port rotation and bunkering infrastructure to allow the possibility of bunkering more than twice per voyage
- Vessel design and tank arrangements
- Evaluation of tanks' capacity
- Intendent lifetime of the vessel
- Long-term fuel availability
- Environmental regulations and policies

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SMART EDUCATIONAL TECHNOLOGIES AS A FACTOR OF SMART SHIPPING DEVELOPMENT

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المستخلص

تواجه الجامعات البحرية الحاجة إلى إعادة التفكير وإعادة هيكلة تجربة التعلم لتوفير مستوى التعليم الذي يتناسب مع تحديات وفرص صناعة الشحن البحري. إحدى الطرق لتحقيق هذا الهدف هي التطبيق الواسع للتقنيات التعليمية الذكية في العملية التعليمية. يُعتبر التعليم من المجالات التي جلبت فيها تكنولوجيا المعلومات العديد من التغييرات، ويُظهر التحول الواضح من الوسائل التعليمية التقليدية إلى البيئة التعليمية المتكاملة باستخدام التقنيات الذكية، قدرة هذه التقنيات على توفير متخصصين ذكيين للعمل في صناعة الشحن الذكي.

تتناول هذه الورقة الجوانب المتعلقة بالتحول الذكي في التعليم البحري وتستعرض القضايا الرئيسية المرتبطة بتطبيق تقنيات الواقع الافتراضي والمعزز في العملية التعليمية، بالإضافة إلى المقترحات بشأن استخدامها بشكل فعال. يتم النظر في العلاقة بين التقنيات التعليمية الذكية والبيئات المهنية في الأنظمة التعليمية المتكاملة البحرية. كما يتم تحديد وتوضيح شروط تنظيم التعلم الغامر ومعايير كفاءته. تُظهر الورقة أن تأثير الغمر يتحقق من خلال التكرار في بيئات تحاكي الأنشطة المهنية الحقيقية. كما يُحدد أن قضية تطوير التعليم الذكي مرتبطة ليس فقط بتطوير التقنيات، ولكن أيضًا بتشكيل جودة التعليم الذي تم اختراع هذه التقنيات من أجله، حيث تظل هذه التقنيات وسيلة وليست هدفًا.

تتناول هذه الورقة تقنيات التعليم الذكي على ثلاثة مستويات، بما في ذلك: عملية التعليم، وإدارتها، والبيئة التي يتم فيها تنفيذها. ويُؤكد على أن تقنيات التعليم الذكي هي عامل رئيسي في تطوير الشحن الذكي. كما يتم عرض نموذج نظام تعلم يجمع بين مزايا النظام التعليمي التقليدي وإمكانات بيئة التعليم المتكاملة. تثبت الورقة أن مفهوم التعليم البحري الذكي، الذي يشمل المرونة، واستخدام عدد كبير من المصادر، وتنوع المحاكيات المستخدمة، هو أحد الاتجاهات الواعدة سواء في التعليم البحري أو في تطوير الشحن الذكي في المستقبل.

الكلمات المفتاحية: التدريب والبيئات المهنية، النظام المتكامل، التعليم البحري، التعليم الذكي، الشحن الذكي.

Abstract
Maritime universities face the need to rethink and restructure the learning experience to provide the level of education, corresponding to the challenges and opportunities of the Maritime industry. One of the ways of achieving the goal is wide implementation of smart educational technologies in educational process. Education is considered as the area in which information technology has brought much changes and an evident shifting from the traditional educational means to the ergatic educational environment by smart technologies use is capable to provide smart shipping industry with smart specialists to work in it.

The offered paper deals with the aspects of intellectualization of Maritime education and shows the main issues associated with the implementation of virtual and argumented reality technologies in educational process and proposals on their efficient use. The correlation between the smart educational technologies and the professional environments in the maritime ergatic systems is considered. The conditions for the organization of immersive learning and criteria of its efficiency are defined and grounded. It is shown that the effect of immersiveness is achieved by repeated immersion under certain conditions that simulate real professional activity. It is determined that the issue of the smart education development is connected not only with the development of technologies, but also with the formation of the education quality, for which these technologies are invented, but still they serve as a means and not goals.

This paper considers smart educational technologies at three levels, including: the process of education, its management, and the environment in which they are effected. It is emphasized that smart educational technologies are the significant factor of Smart shipping development.

A learning system model, combining the advantages of the traditional learning system with the capabilities of the ergatic educational environment resources is offered. The paper proves that the concept of smart maritime education, involving flexibility, the use of a large number of sources, the diversity of used simulators, etc. is one of the promising tendencies both for Maritime education and further smart shipping development.

Keywords: training and professional environments, ergatic system, maritime education, smart education, smart shipping.

1- Introduction

Currently, technological advancements, including automation, have made transportation of people and goods more complex and sophisticated. We undoubtedly understand that automation and technological advances present not only challenges, but also opportunities for different branches of the economy. At the same time the effects of automation and new technologies are understood as not inevitable. They are a result of grounded policy choice. Representatives of business, employers and workers have the power to make digital technology a tool for positive change and they prefer to use them as this decision offers new opportunities.

Maritime transport provides a vital service both to the national economy and the global community. Innovation and technology have always been part of its development and have enabled maritime transport to become a mechanism for constant improvement. Implementation of new technologies, increasing level of automation and the compulsory use of various navigation systems influence the quality of sea industry. However, every new invention changes the nature of work and constantly requires new skill sets of seafarers, that requires time, efforts and money.

2- Smart ports and shipping as a factor of its further development

“Smart port” is a relatively new concept, meaning the ergatic system, taking advantages of technological advancements, namely: Artificial Intelligence, Cloud Computing, Blockchain, Internet of Things, Big Data and Physical Internet. All mentioned is developed and implemented with aim to enhance competiveness, reduce environmental impact, increase productivity, reduce maintenance and operating costs, create safe labour conditions and so on.

Automation and new technologies are introduced progressively in all transport sectors. In maritime transport changes occur not so quickly due to the necessity to be agreed according to the international guidelines and regulations. However, owing to a strong economic benefit is expected, highly automated transport solutions are implemented at the regional level and governed by national legislation or bilateral agreements among adjacent countries.

We live in a period that is characterized by the integration of artificial intelligence and higher degrees of automation and autonomy into the industry. It was always so, but now it is characterized by greater rapid pace of technological developments. As a result, a number of issues in relation to the implications are discussed and solved by different stakeholders and specialists at national and global levels. Much efforts are made by governments, businessmen, shipping companies and researches, to develop navigation support technologies to improve safety and efficiency of ship operations (Makashina, 2016, Makashina, et al. 2021, Makashina and Marichev, 2021 and Makashina, 2022).

No one is arguing that the activity of modern navigators and ship engineers is more cognitive in nature, consisting in analyzing data on the functioning of the systems used in navigation, their understanding, interpretation, operational control of automation, analysis and management of systems, and making complex, responsible solutions (Loginovsky, 2019 and Gilmartin and O’Connor, 2019). Despite the complexity of the implemented information technologies in the sea industry, the prerogative of solving the tasks is the responsibility of a human operator.

All mentioned issues are closely connected with maritime education, which main task is to prepare smart specialists able to serve this complicated sea industry. Maritime universities face the need to modernize and restructure the educational technologies in educational process. Training a specialist for work in one of the most complex ergatic systems, requires great attention to smart training, including immersive environments that allow to simulate future professional conditions and form professional skills that in future can be transferred to real activities. Maritime universities face the challenge of providing the highest possible level of education, corresponding to the challenges and opportunities of the modern Maritime industry. One way of achieving a high level of education for marine professionals is wide implementation of smart technologies.

3- Smart educational technologies

The level of professional knowledge in much depends on the effectiveness of the educational process, which contributes to the formation of the competencies demanded by employers from graduate of Maritime Universities. Education is considered as the area in which information technology has brought much changes and an evident shifting from the traditional educational means to the ergatic educational environment by smart technologies use is capable to provide smart shipping industry with smart specialists to work in it.

We consider the ergatic educational environment as a set of conditions for the performance of educational activities, where the main relationships are the relationship “man-machine”, in our case, “man-simulator”. The conditions for this activity can be divided into external (components of the educational environment) and internal (the educational process itself). The specified set of conditions is created directly by educational actions and is used to realize them.

It should be kept in mind that the ergatic educational environment does not appear, exist and function on its own, and only its competent construction will help determine the result of the educational process. When creating an ergatic educational environment, it is important to rely on an understanding of its complex structure, the interrelationships of its components and their purpose (Sergeev, 2010). At the same time, the main and only purpose of the components is precisely to provide opportunities for educational activities, so its structure and its content are determined by the purpose and objectives of the educational process.

The specific requirements for the training and means of training specialists for sea industry are clearly defined by the International Convention on the Training and Certification of Seafarers and Watchkeeping as amended in 2010 (STCW) (IMO, 2011), which allows the use of simulators as a tool of training and assessing the competence of ship's crew members on an equal basis with ship's equipment. This made it possible to use simulators for various types of training in order to acquire skills in performing basic functions, and today their introduction into the educational process has become not only desirable, but also mandatory. Different types of simulators are used to train and verify the competence of marine specialists within the framework of the requirements of the above said convention. Their choice depends on the possibility of either fully or partially corresponding to the requirements of the Convention, in particular, replacing the internship on board a real ship. The widespread use of simulators in the educational process is explained, first of all, by the fact that simulators allow to reproduce the environment, including the water space, the coastline, piloting, towing, navigation moving ships, loading and unloading operations. A realistic representation of all weather conditions, the effects of visibility and illumination, procedures related to mooring, towing, search and rescue, and special operations turn the simulator into an effective training tool. The psychological readiness of marine specialists affects their ability to withstand extreme external influences, respond quickly and competently to changes in the situation in order to work and to save.

Guiding with requirements of Code A, Section A-I/8 quality standards (IMO, 2011), we agree that smart maritime education is able to provide a sufficiently high level of students' competence, through the development of practice-oriented courses developed by the members of the virtual pedagogical community, working at maritime institutions.

Speaking about intellectualization of Maritime education it is necessary to mention the main issues associated with the implementation of virtual and argumented reality technologies (smart technologies) in educational process. Virtual trends in modern maritime education are becoming the norm, which leads to serious changes in the educational process, and affects all its participants: the organizers of the process, teachers and cadets, turning both knowledge and communication into virtual ones. Virtualization of the maritime educational space, which is determined by external and internal factors, including: development of the marine industry, unlimited access to information, international integration, globalization, national and conventional requirements to the level of marine experts training, growth of accidents in the Maritime transport sector, continuous development of technologies and their implementation on ships and in shore structures and others. Accounting these factors and specific conditions of implementation different types of simulators in maritime education allows design a productive educating process with elements of virtual learning. In light of mentioned, the conditions for the organization of immersive learning and criteria of its efficiency should be defined and grounded.

Immersive learning environment is in the field of view of many scientists and practitioners, and most of them consider this phenomenon as the ergatic learning environments (Makashina, 2016, Makashina, et al. 2021, Makashina and Marichev, 2021 and Makashina, 2022).
These environments are designed taking into account such principles of their organization as: self-organization, selectivity, immersion, presence, activity of a student, mutual orientation in the process of learning communication, physical immediacy and subjective (conscious) mediation, interactivity. As a rule, immersive environments are created with the help of simulators widely used in the learning process at maritime universities. To work effectively in the virtual educational space, the teacher/instructor must be competent both in the field of pedagogy and in the field of information technology.

Smart educational process means performing educational activities by means of advanced technologies, e.g. when the student is immersed in an environment formed by virtual reality technologies, which displays artificially created conditions, but at the same time this student is to solve purely professional tasks.

Considering the conditions for the design and operation of smart training it is important to mention that educational activities are carried out in the proposed conditions (territory, classroom and training center), where participants in educational activities and their means are located. Funds are provided to both the teacher and the student, i.e. those who are the executor of the leading and decisive activity. The connections between the participants are mutual and the result of this interaction affects the correction of the learning immersive environment.

The conditions for organizing immersive learning environments include any means of educational activity: a fund of educational and other literature, equipment for laboratories and training classes visual aids, etc. Special attention is paid to normative documents (curricula, programs, textbooks), which are necessary for adjustment of the content of education, due to changes of the educational standards, improvement of production technologies, development of science and technology, changes in the needs of production, social order, etc.

The effect of immersiveness is achieved by repeated immersion under certain conditions that simulate real professional activity (Makashina, 2022 & Sergeev, 2010) . Opportunities of the virtual world with its powerful potential could be helpful for educators to make learning activity more interesting, creative and useful. In this connection not only appropriate software for maritime students and research from basic programs to the latest simulation software must be available, but methodical and pedagogical support must be continuously provided and updated.
We are absolutely sure that it is impossible to use only smart technologies as the only form of training, but wide smart technologies implementation is necessary and it allows provide flexibility of learning process in an interactive learning environment and personalization and adaptation of learning process.

The smart education concept involves the creation of an intellectual environment for the continuous development of students' competencies in the educational process. Smart learning is implemented based on technological innovations and the Internet, which provides cadets with the opportunity to obtain professional competencies based on a systematic vision and study the content of disciplines, taking into account the need for their continuous updating.

Now-days smart education is developed in three directions, which are closely interconnected, namely: the process of education, the management of the process, and the environment in which it is created and effected. Smart education must be managed, but at the same time it should provide flexibility of educational process taking into account internal and external factors influencing the marine education and possible risks associated with changes of these factors.
Among the main problems associated with the widespread implementation of smart education we distinguish: insufficient quality of electronic educational resources; the ineffectiveness of control methods and assessment; necessity of compliance with both national and international standards; intellectual property issues; automation of administrative tasks, compatibility of programs among different operating systems.

When speaking about the standard, quality is always meant. Quality is usually understood as the objective characteristics of the objects that appear in the aggregate of their properties. Under the "2010 Manila Amendments" to the Standards of Training, Certification and Watchkeeping for

Seafarers (STCW) Convention and Code, Quality Standard System (QSS) requirements require "in accordance with the provisions of section A-I/8 of the STCW Code, all training, assessment of competence, certification, including medical certification, endorsement and revalidation activities carried out by non-governmental agencies or entities under its authority are continuously monitored through a quality standards system to ensure achievement of defined objectives, including those concerning the qualifications and experience of instructors and assessors (IMO, 2011).

It is common understanding, that the quality of smart education of specialists is determined by the quality of educational programs and content; quality of potential of teaching personnel; quality of potential of the applicants; quality of educational technologies; quality of resource provision.
The structure of the material proposed for mastering in the virtual space must comply with certain rules, i.e. include: basic material that provides a presentation of the content of the educational subject; additional material related to the basic material by a clear navigation system and serving to expand and deepen basic knowledge; explanatory texts accompanying the key terms of the basic material, graphic images; control the component. Moreover, the main requirements include: multimedia, interactivity, attraction of symbolic information (text, hypertext), static realistic and synthesized visual series, sound series and dynamic video series.

We have allocated organizational and pedagogical conditions for the organization of smart training as follows:

- sequence of actions of students in accordance with traditional practical exercises;
- development of a model of training system for the organization of independent work of students;
- individualization of the learning process;
- the visibility and availability, including control of acquired knowledge;
- feedback that allows you to adjust the current educational process taking into account the current state of knowledge of the student.

Educational and methodical conditions of smart training functioning can be distinguished as following:

- due to preparation of a teacher/instructor to work in smart educational environment;
- development of pedagogical support;
- application of the most effective teaching methods;
- provision with modern technological means;
- regularly updated software for simulators;
- provision of teaching materials in electronic form etc.,

Moreover, the principles of the organization of the smart educational process can be formulated as the following:

- scientific content of information material (selection of the most important elements of knowledge) should be updated;

- provision of feedback must allow choose the most appropriate forms depending on the formed level of students' knowledge;
- feedback should be considered as the main condition of the educational process;
- cumulative effect is to be realized in the form of accumulation knowledge as a result of responses to test tasks and repeated reference to the theory;
- individualization of learning should be achieved.

Work in the smart educational environment involves adherence to certain methodological requirements for the creation of educational electronic materials:
- educational electronic material must meet the requirement of completeness of the content;
- educational electronic material should be built on the principle from simple to complex;
- pedagogical methods and technologies should be used in accordance with the specifics of each certain science and its corresponding discipline.

The software, used for smart educational process should provide:
- comfortable learning environment;
- availability of information material;
- dynamic feedback between the user and the training system;
- the possibility of returning to the wrong tasks and wrong answers;
- availability of reference material on the subject.

We hope that the pedagogical, technological and practical aspects of how smart education can potentially benefit Maritime education and its communities should be accounted while arranging educational process.

The processes of changes in the Maritime educational space occurs due to the strengthening of virtual trends arising in sea industry, so the concept of smart maritime education, involving flexibility, the use of a large number of sources, the diversity of used simulators, etc. is one of the promising tendencies both for Maritime education and further smart shipping development.

4- Conclusion

The challenges of automation, new technology and the future of work are some of the most important experience facing workers today. Transport workers should be equipped with the required knowledge, skills and expertise for the jobs of today and tomorrow. The Maritime ergatic technological systems is characterized by the rapid development and introduction of modern technologies into production and this demands specialists to work in it, due to the fact that in the shipping industry, the human element is recognized as the main source of risk for safe and efficient shipping. Functioning in the smart technological sphere like sea industry requires smart specialists, capable to overcome risks and difficulties while performing complicated professional functions both onboard and ashore. Smart specialists are result of smart education and in this connection responsibility of Maritime Universities is constantly increasing.

Despite the wide interest in the use of training complexes in the educational process, the task of choosing the optimal composition of training equipment for training of smart specialists continues to be relevant, due to the constant development of technology and the search for ways to achieve the quality of training. No matter how unique the simulator is, for its effective use, appropriate conditions in the educational environment should be created.

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